7. Method to Assess Depressional Closed Wetlands

The method includes models for the following functions.

- Potential for Removing Sediment
- Potential for Removing Nutrients
- Potential for Removing Heavy Metals and Toxic Organics
- Potential for Reducing Peak Flows
- Potential for Decreasing Downstream Erosion
- Potential for Recharging Groundwater
- General Habitat Suitability
- Habitat Suitability for Invertebrates
- Habitat Suitability for Amphibians
- Habitat Suitability for Anadromous Fish
- Habitat Suitability for Resident Fish
- Habitat Suitability for Wetland-associated Birds
- Habitat Suitability for Wetland-associated Mammals
- Native Plant Richness
- Potential for Primary Production and Organic Export

7.1 Potential for Removing Sediment — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.1.1 Definition and Description of Function

Removing sediment is defined as the wetland processes that retain sediment in a wetland, and keep them from going to downgradient surface waters in the watershed.

All depressional closed wetlands have the potential to remove sediment at the highest levels because they have no outlet. All sediments coming into the wetland are retained and not released to surface waters.

7.1.2 Qualitative Rating of Opportunity

The opportunity of AUs in this subclass to remove sediment is a function of the level of disturbance in the landscape. Relatively undisturbed watersheds in the lowlands in western Washington will carry much lower sediment loads than those that have been impacted by development, agriculture, or logging practices (Hartmann et al. 1996, and Reinelt and Horner 1995). The opportunity that an AU has to remove sediment is, therefore, linked to the amount of development, agriculture, or logging present in the upgradient part of its contributing basin.

Users must make a qualitative judgement on the opportunity of the AU to actually trap sediment by considering the land uses in the contributing watershed and the condition of its buffer. The opportunity for an AU in the depressional closed subclass to remove sediments is **"Low"** if most of its contributing watershed is undeveloped, not farmed, or not recently logged. Densely vegetated watersheds (e.g., undisturbed forest) stabilize soils, reduce runoff velocity, and thus export less sediment (Bormann et al. 1974, Chang et al. 1983). The opportunity is **"Low"** if the AU receives most of its water from sheetflow rather than from an incoming stream, and it has a good vegetated buffer. Vegetated buffers will trap sediments coming from the surrounding landscape before they reach the AU. A buffer that is only 5 m wide will trap up to 50% of the sediment while one that is 100 m wide will trap approximately 80% of the sediments (Desbonnet et al. 1994). The opportunity is also **"Low"** if the AU receives most of its water from groundwater since this source of water does not carry any sediments.

The opportunity for the AU to remove sediments is **"High"** is the contributing watershed is mostly agricultural or there is recent construction or clear-cut logging in it. In contrast to undisturbed watersheds, urban, agricultural, or logged watersheds have more exposed soils and thus higher sediment loadings. AUs with upgradient disturbances to the watershed will have a greater opportunity to remove sediment and improve water quality than those in undisturbed watersheds. In general, AUs that are in urban or rapidly urbanizing watersheds will usually have some on-going construction. These can all be assumed to have a **"High"** opportunity.

The opportunity to remove sediment is **"Moderate"** if the activities that generate sediment are a small part of the contributing watershed, or if they are relative far away from the AU. The user will have to use their judgement in deciding whether the opportunity is moderate or high, and document their decision on the summary page of the assessment.

7.2 Potential for Removing Nutrients — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.2.1 Definition and Description of Function

Removing Nutrients is defined as the wetland processes that remove nutrients (particularly phosphorus and nitrogen) present in surface waters, and keep them from going to downgradient waters in the watershed.

The major processes by which depressional closed wetlands reduce nutrient loadings are: 1) through the trapping of sediment to which phosphorus is bound, 2) removal of phosphorus by adsorption to soils that are high in clay content or organic matter, and 3) removal of nitrogen through nitrification and denitrification in alternating oxic and anoxic conditions (Mitsch and Gosselink 1993). Even though closed systems have no surface water outflows, the processes described remove nutrients from waters reaching the wetland that might otherwise flow into groundwater.

Depressional closed wetlands all have the same potential to trap sediments because no surface water leaves the wetland. Thus, phosphorus removal is modeled only as adsorption to soils. Nitrogen removal is modeled as a function of primary productivity. In depressional closed wetlands much of the nitrogen removal will occur through the transformation of inorganic nitrogen to organic nitrogen. The organic nitrogen cannot be exported because there are no surface outlets and it will remain within the wetland. Furthermore, the transformation of inorganic to organic nitrogen removes the nutrient as a contaminant in groundwater that may be leaving the wetland.

7.2.2 Assessing this Function for Depressional Closed

The potential that wetlands in the depressional closed subclass have to remove phosphorus from incoming surface waters is modeled as the process of soil adsorption. The sorptive properties of the soils are characterized based on the areal extent of organic or clay soils since these are the two types of soils with the highest rates of adsorption of phosphorus (Mitsch and Gosselink 1993).

The potential of wetlands to remove nitrogen is modeled using the area of the wetland that has a high level of primary production using vegetation types as an indicator.

7.2.3 Model at a Glance

Depressional Closed — Removing Nutrients

Process	Variables	Measures or Indicators
Phosphorus Removal	**Vsorp**	% of AU with clay soil; % of AU with organic soil
Nitrogen Transformation	**Vvegcover**	Total area of vegetation in AU
	Index:	(Vsorp + Vvegcover) / Score from reference standard site

7.2.4 Description and Scaling of Variables

$\boldsymbol{V_{sorp}}$ – The sorptive properties of the surface soils present in an AU.

Rationale: The uptake of dissolved phosphorus through adsorption to soil particles is highest when the soils are high in clay content or organic content (Mitsch and Gosselink 1993).

Indicators: The indicator for sorptive properties of soils is the extent of the AU with high content of clay or organic matter.

Scaling: AUs with large areas of organic soils or clay soils (> 30% clay) are scaled higher than those with less. The actual scaling is calculated based on the area of mineral soil that is not clay or organic for ease of computation. AUs with less than 50% mineral soils (not clay or organic) are scored a [1]. Those with 50 –95% mineral soils are scored a 0.5, and those with >95% mineral soils (not clay or organic) are scored a [0].

$\boldsymbol{V}_{vegcover}$ – The total area of the AU that is vegetated, as a % of the total area.

Rationale: Nitrogen removal is modeled as a function of primary productivity in depressional closed wetlands because organic matter is trapped within the system. Decomposed material (N) cannot leave the system. The assumption made by the Assessment Teams is that the average amount of primary production per acre in a wetland is most directly related to the amount of its total plant cover. AUs that are mostly open water will have lower primary productivity than those that are completely vegetated.

Indicators: No indicators are needed. The % of the AU that is vegetated is determined in the field or from aerial photographs.

Scaling: AUs that are completely vegetated are scored a [1] for this variable. Scaling for the others is proportional, based on the % area that is vegetated (%area / 100).

7.2.5 Calculations of Potential Performance

Depressional Closed – Removing Nutrients

Variable	Description of Scaling		Score for Variable	Result
Vsorp	*Highest:*	Non-clay mineral soils are <50% of area	If D47.3 < = 1, enter "1"	
	Moderate:	Non-clay mineral soils are 50-95% of area	If D47.3 = 2, enter "0.5"	
	Lowest:	Non-clay mineral soils are >95% of area	If D47.3 = 3, enter "0"	
Vvegcover	*Highest:*	100% of the AU has a cover of vegetation	If calculation = 1 then enter "1"	
	Lowest:	0% of the AU has a vegetation cover	If calculation = 0 then enter "0"	
	Calculation:	Scaling = (% of AU with veg cover/100)	Enter result of calculation	
	Calculate [sum(D14.1 to D14.6)]/100			
			Total of Variable Scores:	
Index for Removing Nutrients = Total x 5.0 rounded to nearest 1				
			FINAL RESULT:	

7.2.6 Qualitative Rating of Opportunity

The opportunity of AUs to remove nutrients should be judged based on the characteristics of its upgradient watershed. Relatively undisturbed watersheds in the lowlands in western Washington will carry much lower nutrient loads than those that have been impacted by development, agriculture, or logging practices (Hartmann et al. 1996, and Reinelt and Horner 1995). The opportunity that an AU has to remove nutrients is, therefore, linked to the amount of development and agriculture present in the upgradient part of its contributing basin. In addition, there are areas in western Washington that have naturally high phosphorus levels in groundwater (Van Denburgh and Santos 1965). AUs in these areas will have an increased opportunity to remove phosphorus if groundwater is a major source of water to the AU.

Users will have to make a qualitative judgement of the opportunity the AU actually has to remove nutrients by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional closed subclass to remove nutrients is **"Low"** if most of its contributing watershed is undeveloped, or not farmed. The opportunity for the AU to remove nutrients is **"High"** if the contributing watershed is mostly agricultural. The opportunity to remove nutrients is **"Moderate"** if the activities that generate nutrients are a small part of the contributing watershed, or if they are relatively far away from the AU. It should also be considered moderate if the AU is located in a region of high concentrations of phosphorus in groundwater. AUs fed by groundwater high in phosphorus content have a greater opportunity to remove phosphorus through soil adsorption. [See results from study of groundwater phosphorus and removal in the Patterson Creek 12 AU discussed in Reinelt and Horner (1995)]. Areas in western Washington with high levels of phosphorus in groundwater can be identified from data presented in Van Denburgh and Santos (1965).

The user must use their judgement in rating the opportunity, and document their decision on the data sheet (Part 2).

7.3 Potential for Removing Metals and Toxic Organic Compounds — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.3.1 Definition and Description of Function

Removing Metals and Toxic Organic Compounds is defined as the wetland processes that retain toxic metals and toxic organic compounds coming into the wetland, and keep them from going to downgradient waters in the watershed.

The major processes by which closed wetlands reduce metals and toxic organic loading to groundwater are through sedimentation of particulate metals, adsorption, chemical precipitation, and plant uptake. Metals that tend to have a high particulate fraction, such as lead (Pb), may be removed through sedimentation. Adsorption is promoted by soils high in clay content or organic matter. Chemical precipitation is promoted by wetland areas that are flooded and remain aerobic, as well as by low pH values (Mengel and Kirkby 1982). Finally, plant uptake is maximized when there is significant wetland coverage by emergent plants (Kulzer 1990).

7.3.2 Assessing this Function for Depressional Closed Wetlands

The potential that depressional closed AUs have to remove metals and toxic organic compounds is assessed by their characteristics that indicate potential for adsorption, precipitation and uptake by plants. All closed systems have the potential to trap sediments at the highest levels. Therefore, the process of sedimentation is not included in the model for this subclass.

Model at a Glance

Depressional Closed — Removing Metals and Toxic Organics

Process	Variables	Measures or Indicators
Adsorption	**Vsorp**	% of AU with clay soil; % of AU with organic soil
Precipitation	**Vph**	pH of interstitial water
Plant Uptake	**Vtotemergent**	% area of emergent vegetation in AU
Plant Uptake	**Veffectarea1**	% of AU that is seasonally inundated
	Index:	Vsorp + Vph + Vtotemergent + Veffectarea1 / Score from reference standard site

7.3.4 Description and Scaling of Variables

V_{sorp} – The sorptive properties of the surface soils present in an AU.

Rationale: Adsorption of both toxic metals and toxic organic compounds is highest when the soils have a high cation exchange capacity (Mengel and Kirkby 1982). These are the soils high in either clay or organic content.

Indicators: The indicator for sorptive properties of soils is the extent of the AU with high content of clay or organic matter.

Scaling: AUs with large areas of organic or clay soils (> 30% clay) are scaled higher than those with less. The actual scaling is calculated based on the area of mineral soil that is not clay or organic for ease of computation. AUs with less than 50% mineral soils (not clay or organic) are scored a [1]. Those with 50 –95% mineral soils are scored a 0.5, and those with >95% mineral soils (not clay or organic) are scored a [0].

V_{pH} – The pH of interstitial water.

Rationale: Many toxic metals are precipitated out of water when the pH is low. Although there are a few, such as lead, that precipitate out at high pH, the assessment team judged that a low pH was better for removing toxic metals overall. Furthermore, the high pH needed to precipitate a few metals (>9) are rarely, if ever, encountered in the wetlands of western Washington.

Indicators: pH can be measured directly using pH tabs.

Scaling: Low pH (<= 4.5) in the interstitial waters of an AU results in the highest score [1] and optimal removal. A pH between 4.5 and 5.5 scores a [0.5] and a pH > 5.5 score a [0].

$V_{totemergent}$ – The areal extent (as % of AU) of emergent plant species in both the emergent zone and as an herbaceous understory to areas of forest and scrub/shrub.

Rationale: Emergent species have, in general, been found to sequester metals and remove oils and other organics better than other plant species (Hammer 1989; Horner 1992). AUs dominated by emergents were judged to sequester toxic metals and remove organic compounds better than those dominated by forest or scrub/shrub. Furthermore, the emergent vegetation and herbaceous understory support a higher microbial population that can decompose organic toxicants. This is due to a larger surface area exposed to incoming water.

Indicators: No indicators are needed. The areal extent (as % of AU) of emergent species and herbaceous understory is estimated directly.

Scaling: The scaling of the variable is based on the percent of the AU covered by emergent species (using the Cowardin definition) and by an herbaceous understory. AUs with a 100% cover of emergents + understory are scaled as [1]. AUs with a cover of less than 100% are scaled proportionally as %area/100.

$V_{effectarea1}$ – The area of the AU over which the removal of metals and toxic organic compounds is expected to take place. Some parts of an AU may never be inundated by surface waters and thus will not remove toxics from surface waters.

Rationale: In this assessment method, an index for an AU is calculated on a "per acre" basis. An index for an AU is then calculated by multiplying its "per acre" score by its area. Thus, a correction factor representing the area of the AU that actually performs the function, relative to its overall size, is needed.

Indicators: In western Washington, there is some difficulty in establishing the area of an AU that is regularly flooded because the water regime can be so variable for many AUs. The indicator chosen by the Assessment Teams to represent this variable is the area of the AU that is inundated or flooded on a seasonal basis. The area of surface water inundation during the summer must be determined by indicators such as water marks, deposition lines, or other discoloration on vegetation or rocks.

Scaling: This variable is scaled based on the percentage of the AU that is seasonally inundated. AUs that are seasonally inundated over their entire surface (100%) score a [1]. Areas or inundation less than 100% are scaled proportionally as %area/100.

7.3.5 Calculations of Potential Performance

Depressional Closed – Removing Metals and Toxic Organics

Variable	Description of Scaling		Score for Variable	Result
Vsorp	*Highest:*	Non-clay mineral soils are <50% of area	If D47.3 < =1, enter "1"	
	Moderate:	Non-clay mineral soils are 50-95% of area	If D47.3 = 2, enter "0.5"	
	Lowest:	Non-clay mineral soils are >95% of area	If D47.3 = 3, enter "0"	
Vph	*Highest:*	pH less than of equal to 4.5	If D26.1 < = 4.5, enter "1"	
	Moderate:	pH between 4.5 and 5.5	If D26.1 > 4.5 and < = 5.5, enter 0.5	
	Lowest::	pH greater than 5.5	If D26.1 > 5.5, enter "0"	
Vtotemergent	*Highest:*	100% of AU has herbaceous understory and/or emergents	If calculation = 1, enter "1"	
	Lowest:	AU has 0% of emergents	If D14.5 + D16 = 0, enter "0"	
	Calculation:	Scaling = (% of AU with emergents + understory/100)	Enter result of calculation	
	Calculate D14.5 + (D16/100x sum (D14.1 to D14.4)) /100 to get result			
Veffectarea1	*Highest:*	100% of the AU is seasonally ponded or inundated	If D8.1 =100, enter "1"	
	Lowest:	0% of the AU is seasonally ponded	If D8.1 = 0, enter "0"	
	Calculation:	Scaling = (% of AU inundated/100)	Enter result of calculation	
	Calculate D8.1/100 to get result			
			Total of Variable Scores:	
		Index for Removing Metals and Toxic Organics = Total x 2.23 rounded to nearest 1		
			FINAL RESULT:	

7.3.6 Qualitative Rating of Opportunity

The opportunity of AUs in these subclasses to remove metals and toxic organic compounds should be judged using the characteristics of the upgradient watershed. Those land uses or activities that contribute metals and toxic organics to surface waters include urban and residential areas and agricultural activities involving pesticide/herbicide applications.

Relatively undisturbed watersheds in the lowlands in western Washington will carry much lower loads of toxic chemicals than those that have been impacted by residential, urban development or agriculture (Reinelt and Horner 1995). The opportunity that an AU has to remove toxic compounds is, therefore, linked to the amount of development and agriculture present in the upgradient part of its contributing basin

Users will have to make a qualitative judgement of the opportunity the AU actually has to remove toxic compounds by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional closed subclass to remove toxic compounds is **"Low"** if most of its contributing watershed is undeveloped, and not farmed.

The opportunity for the AU to remove nutrients is **"High"** if the contributing watershed is mostly agricultural, urban, commercial, or residential.

The opportunity is **"Moderate"** if the activities that generate toxic compounds are a small part of the contributing watershed, or if they are relative far away from the AU.

The user will have to use their judgement in deciding whether the opportunity is moderate or high, and document their decision on the summary sheet (Part. 2).

7.4 Potential for Reducing Peak Flows — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.4.1 Definition and Description of Function

Reducing Peak Flows is defined as the wetland processes or characteristics by which the peak flow in the downgradient part of the watershed is reduced during major rainfall events that cause flooding.

Surface water that may otherwise cause flooding is stored to a greater degree in a wetland than typically occurs in terrestrial environments. Wetlands reduce peak flows on streams and rivers by slowing and storing stream flow in overbank areas, and by holding back runoff during high water periods when it would otherwise flow directly downgradient and increase flooding.

Reduction in peak flows is often called water storage in other assessment methods (e.g. Brinson et al. 1995). The assessment team, however, decided to model more than just water storage. One of the major hydrologic functions of wetlands in watersheds of western Washington is to attenuate the severity of peak flows during flood events. The level of reduction in flow provided by an AU is a result of both the storage present within it and the amount of surface water entering the AU. AUs that have the same amount of storage may not reduce peak flows by the same amount if one has 10 times the volume of water entering it than the other during a flood event.

7.4.2 Assessing this Function for Depressional Closed Wetlands

All depressional closed wetlands have the potential to reduce peak flows at the highest levels because they have no outlet. All floodwaters coming into the wetland are retained and not released to surface waters.

7.4.3 Qualitative Rating of Opportunity

The opportunity for an AU to reduce peak flows will increase as the water regime in the upgradient watershed is destabilized. Research at in western Washington has shown that peak flows increase as the percentage of impermeable surface increase (Reinelt and Horner 1995). The opportunity should therefore be judged by the amount of upgradient watershed that is developed.

Users will have to make a qualitative judgement on the opportunity of the AU to actually reduce peak flows by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional closed subclass is **“Low”** if most of its contributing watershed is undeveloped, not farmed, or not recently logged. The opportunity is also **“Low”** if the AU receives most of its water from groundwater, rather than from an incoming stream, ditches, or storm drains.).

The opportunity for the AU is **“High”** is the contributing watershed is mostly urban or high density residential. The opportunity is **“Moderate”** if the development is a small part of the contributing watershed, if the upgradient watershed is mostly agricultural, or if these areas are relative far away from the AU. Users must use their judgement to decide whether the opportunity is low, moderate, or high, and document their decision on the summary sheet (Part 2).

7.5 Potential for Decreasing Downstream Erosion — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.5.1 Definition and Description of Function

Decreasing Downstream Erosion is defined as the wetland processes that decrease erosion of stream channels further downstream in the watershed by reducing the duration of erosive flows.

An AU performs this function if it stores excess runoff during and after storm events, before slowly releasing it to downgradient waters. This is similar to the function provided by stormwater retention/detention (R/D) ponds that are designed to prevent downstream erosion in developed areas. The AU decreases downstream erosion by reducing the duration of erosive flows (erosive flows are the high velocity, high volume flows that cause much of the erosion in a watershed).

The major processes by which wetlands reduce the duration of erosive flows is by storing some of the peak flows and thus reducing the time during which erosive flows occur, and by reducing the velocity of water flowing through the AU during a storm event. Erosive flows in a watershed occur above a certain velocity based on geomorphology. By reducing the velocity in general, an AU can reduce the overall time during which the erosive velocities occur.

The function of decreasing downstream erosion is closely related to that of reducing peak flows because a reduction in peak flows will also result in a reduction of velocity. All of the variables used in the "peak flow" model are used for this function as well. One way to consider the function being assessed is to ask "What would happen to erosive flows in the watershed if the AU were filled?".

7.5.2 Assessing this Function for Depressional Closed Wetlands

All depressional closed wetlands have the potential to decrease downstream erosion at the highest levels because they have no outlet. All floodwaters coming into the wetland are retained and not released to surface waters.

7.5.3 Qualitative Rating of Opportunity

The opportunity for an AU to decrease erosion will increase as the water regime in the upgradient watershed is destabilized. Research in western Washington has shown that peak flows and velocities increase as the percentage of impermeable surface increase (Reinelt and Horner 1995). The opportunity should therefore be judged by the amount of upgradient watershed that is developed.

Users will have to make a qualitative judgement on the opportunity of the AU to actually decrease erosion by considering the land uses in the contributing watershed. The opportunity for an AU in the depressional closed subclass is **"Low"** if most of its contributing watershed is undeveloped, not farmed, or not recently logged. The opportunity is also **"Low"** if the AU receives most of its water from groundwater, rather than from an incoming stream, ditches, storm drains, or other surface water sources.

The opportunity for the AU is **"High"** is the contributing watershed is mostly urban or high density residential. The opportunity to is **"Moderate"** if the development is a small part of the contributing watershed, if the upgradient watershed is mostly agricultural, or if these areas are relative far away from the AU. Users will have to use their judgement in deciding whether the opportunity is low, moderate or high, and document their decision on the summary sheet (Part. 2).

7.6 Potential for Recharging Groundwater — Depressional Closed Wetlands

> **Note**: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.6.1 Definition and Description of Function

Recharging Groundwater is defined as the wetland processes by which surface water coming into a wetland is transported into subsurface water that moves either into unconfined aquifers or into interflow. It is the "interflow" that supports flows in streams during the dry season.

Wetlands recharge groundwater by holding back precipitation and surface water. This water then may infiltrate into the groundwater system.

There are two aspects of recharge. The first is the recharge of shallow subsurface flows (called interflow) that help maintain low flows in streams during the dry season. The second aspect of the function is recharge of subsurface aquifers. The wetland process that is important to both aspects of the function is infiltration.

The first draft of the assessment methods included separate functions for the recharge of interflow (called Maintaining Seasonal Low Flows) and the recharge of unconfined aquifers (called Recharging Unconfined Aquifers). During the field calibrations, however, we were unable to characterize the conditions of the subsurface geology and soils well enough to determine if water infiltrating through the wetland would become part of the "interflow" or part of an unconfined aquifer. As a result, the functions were combined, and the model only assesses the relative rates of infiltration in an AU.

The contribution of a wetland to seasonal low flows is the water that enters the groundwater system during the wet season. Wetlands in western Washington will usually dry out by the time dry season low flows need to be maintained. Surface waters stored within the wetland will usually have evaporated, infiltrated, or flowed out.

7.6.2 Assessing this Function for Depressional Closed Wetlands

The potential for AUs to recharge groundwater is modeled as the relative rate of infiltration. Two variables are used; the first is a qualitative rating of the permeability of the soils within the unit; and the second is the percent of the AU with seasonal inundation.

7.6.3 Model at a Glance

Depressional Closed — Recharging Groundwater

Process	Variables	Measures or Indicators
Infiltration	**Vinfilt**	Rating infiltration rate of soils
	Veffectarea2	Area of seasonal inundation minus permanent open water
	Index:	Vinfilt + Veffectarea2 / Score from reference standard site

7.6.4 Description and Scaling of Variables

V_{infilt} – A qualitative rating of the infiltration capacity of the soils in the AU.

Rationale: Infiltration can occur only where the soils are permeable. Many AUs in the lowlands of western Washington are formed on impermeable shallow tills or have extensive peat deposits. These conditions hinder the recharge of groundwater. Recharge is an important process only if the soils have high sand, gravel or cobble content, and a low content of clays, silts, or organic matter. The layer with the lowest infiltration rate in the top 60 cm is used to develop the rating.
Indicators: The indicator of infiltration is the relative amount of sand, silt, gravel, clay, or organic matter present in soils. Infiltration is rated down to a depth of 60 cm (2 ft).
Scaling: Soils with more than 50% of gravel and cobbles and less than 30% of clay or organic matter are scaled a [1] since these have the highest infiltration rate. Soils with more than 50% sand and less than 30% of clay or organic matter are scaled a [0.5]. Soils with more than 30% clays or organic matter are scaled a [0.1] because these have little or no infiltration.

$V_{effectarea2}$ – The area of the AU where infiltration occurs. The variable is measured as the percent of the AU that is seasonally inundated minus the area that has permanent open water.
Rationale: Infiltration can occur only where the surface waters provide a hydraulic head to push water into the soils. Areas of permanent open water, however, are judged by the assessment team not to be permeable. Areas of permanent water usually develop a layer of fine sediments, often organic, that severely reduce infiltration. The effective area where infiltration occurs, therefore, is considered only to be the area that is seasonally inundated (area that is permanently inundated is excluded from this variable).
Indicators: The indicator for the effective area is the seasonally inundated area minus the area of permanent inundation.
Scaling: AUs that are completely inundated seasonally and have no permanent open water are scored a [1] for this variable. Scaling for the others is proportional, based on the % area that is only seasonally inundated (%area / 100).

7.6.5 Calculations of Potential Performance

Depressional Closed – Recharging Groundwater

Variable	Description of Scaling		Score for Variable	Result
Vinfilt	*Highest:*	Gravel, cobble >50% of soil and silt, clays, and organics <30%	If D48.1 = 1, enter "1"	
	Moderate:	Sand >50% of soil and silt, clays, and organics <30%	If D48.2 = 1, enter "0.5"	
	Lowest:	Silt, clay, and organics > 30% of soil	If D48.3 = 1, enter "0.1"	
Veffectarea2	*Highest:*	100% of the AU, is seasonally ponded or inundated with no permanent open water	If calculation = 1 enter "1"	
	Lowest:	0% of the AU is seasonally ponded	If calculation = 0, enter "0"	
	Calculation:	Scaling = (% of AU inundated/100)	Enter result of calculation	
	Calculate (D8.1-(D8.3+D14.6))/100			
			Total of Variable Scores:	
			Index for Recharging Groundwater = Total x 6.67 rounded to nearest 1	
			FINAL RESULT:	

7.6.6 Qualitative Rating of Opportunity

Groundwater is an integral component of the water cycle throughout western Washington. The Assessment Teams have judged that all AUs in the lowlands of western Washington have a **"High"** opportunity to recharge either interflow or an unconfined aquifer if the surface soils within the AU are permeable enough. The assumption is that all AUs have some link to groundwater.

7.7 General Habitat Suitability — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.7.1 Definition and Description of Function

General Habitat Suitability is defined as the characteristics or processes present in a wetland that indicate a general habitat suitability for a broad range of wetland dependent species. It also includes processes or characteristics within a wetland that help maintain ecosystem resilience (characteristics that are important in maintaining the ecosystem when it is disturbed). The assessment model attempts to assess how well an AU provides habitat for fauna. The model is not focused on individual species groups, but rather it emphasizes the elements in an AU that help support a range of different animal species. Native Plant Richness is addressed in a separate function. The "General Habitat Suitability" function may be used as a surrogate for "General Wildlife Habitat," though it is not restricted to the common definition of "wildlife" as mammals, and birds. The general habitat function incorporates elements that are important to invertebrates and decomposers as well as to amphibians.

Many of the variables used to assess the performance of an AU for general habitat are also used in the assessments of habitat suitability for individual species groups. The SWTC and Assessment Teams, however, thought it important to assess General Habitat Suitability in broad terms as well as the individual species groups.

7.7.2 Assessing this Function for Depressional Closed Wetlands

An AU in the depressional closed subclass provides suitable habitat if it has a complex physical structure, high plant richness, and the presence of seasonal or year-round standing water. Suitability also increases if there is high interspersion of habitat types within the AU.

The model is additive so that physical structures in the wetland (i.e. channels, upland/wetland edge, etc.) and biologic characteristics such as plant assemblages add to the general habitat suitability of an AU. The operative assumption is that the suitability of an AU for all species groups increases as the number of characteristics in the AU increase.

The presence of urban or high-density residential areas around an AU is included as a variable to reflect the potential for a reduction in the performance of this function. Development in the area around a wetland can result in increased surface water velocities, surface water volumes, pollution loadings, and changes in the water regime that have an impact on the suitability of a wetland as habitat (Reinelt and Horner 1995).

7.7.3 Model at a Glance

Depressional Closed — General Habitat Suitability

Characteristics	Variables	Measures or Indicators
Structural heterogeneity (applies to all variables)	**Vbuffcond**	Descriptive table of conditions in buffer
	V%closure	% area of canopy closure in AU
	Vstrata	Maximum number of strata in any one assemblage
	Vsnags	Categories of snags present
	Vvegintersp	Interspersion between vegetation classes -diagrams
	Vlwd	Categories of LWD present
	Vhydrop	Number of water regimes present
	Vwaterdepth	Number of water depth categories present
	Vwintersp	Characteristics of water interspersion - diagrams
	Vprichness	Number of plant species present
	Vmature	Presence/absence of mature trees
	Vedgestruc	Structural complexity of AU edge
Reducers		
Surrounding land uses	**Vupcover**	Land uses within 1 km of wetland
	Index:	(Vbuffcond + V%closure + Vstrata + Vsnags + Vvegintersp + Vlwd + Vhydrop + Vwaterdepth + Vwintersp + Vprichness + Vmature + Vedgestruc) x Vupcover / Score for reference standard site

7.7.4 Description and Scaling of Variables

$V_{buffcond}$ – Condition of buffer within 100 m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The condition of the buffer affects the ability of the AU to provide appropriate habitat for some species groups (Zeigler 1992). Terrestrial species using the wetland that are dependent upon upland habitats for a portion of their life cycles are benefited by the presence of relative undisturbed upland community types immediately surrounding the wetland. Although all guilds may not require upland habitats for a portion of their life-cycle, some species are sensitive to impact (particularly those that cannot escape to other refuge habitats) and the presence of humans and domestic animals in close proximity to the wetland may impact them.

Indicators: This variable is assessed using the buffer categories described in Part 2.

Scaling: AUs with buffers that are relatively undisturbed for at least 100 m around 95% of the AU (buffer category #5) are scaled a [1]. The categories between 0-5 are scaled proportionally as 0, 0.2,0.4, 0.6, and 0.8.

$V_{\%closure}$ – The % canopy closure of woody vegetation higher than 1 m over the entire AU.

Rationale: The Assessment Teams judged canopy closure an important general habitat feature because it: 1) influences the micro-climate within the AU; 2) is a source of organic material to the duff layer, 3) stabilizes soils within the AU; and 4) provides structural complexity for perches, nest sites and invertebrates. All of these factors contribute to increasing faunal richness.

Indicators: No indicators are needed to assess this variable. Canopy cover can be estimated directly.

Scaling: Generally, a canopy provides the best habitat conditions when the closure is moderate. The data from the reference sites suggests that a canopy closure between 30 and 60% is best (scaled as a [1]). Either more or less canopy cover is not as good. Canopy closures between 10-29% and 61-100% were scored a [0.5], and canopy closures either higher or lower than these were scored a [0].

V_{strata} – The maximum number of strata in any single plant assemblage. A plant assemblage (see Part 2 for operational definition of a plant assemblage) can have up to 6 strata (layers: trees, shrub, low shrub, vine, herbaceous, mosses, and bryophytes). To count as a stratum, however, the plants of that stratum must have 20% cover in the assemblage in which they are found.

Rationale:. A greater number of strata provide more niches for different species than fewer strata. Strata are important to wildlife because different species utilize different strata for feeding, cover, and reproduction. Some species use a single strata exclusively throughout their life history (many invertebrates, for example, and some small mammal species) (Andrewartha and Birch, 1984). Other species, on the other hand, require several strata to meet their life requirements. Consequently, an increase in number of strata will increase the suitability of an AU by increasing the potential species richness.

Indicators: No indicators are needed to assess this variable. The number of strata can be estimated directly.

Scaling: AUs with 6 strata are scored a [1] for this variable. AUs with only one are scored a [0]. AUs with 2, 3, 4 and 5 strata are scaled proportionally as 0.2, 0.4, 0.6, and 0.8 respectively.

***V_{snags}* –** The number of different snag categories, and their size, based on states of decomposition, found in the AU.

Rationale: Snags are the source of cavities in standing woody vegetation that provides habitat for numerous bird and mammal species. Many species of birds and mammals utilize cavities for nesting, roosting, denning, and/or refuge. Snags are invaded by invertebrates and other organisms of decay, which in turn provide food for many species of wildlife (Davis et al. 1983). In addition, when snags fall, they contribute to the overall health of an ecosystem by decaying, which contributes nutrients to the soil (Maser et al. 1988). Furthermore, the presence of large snags was judged to be more important as a habitat feature than small snags because they have the potential for larger cavities as well as small ones; thus providing an additional niche in the wetland.

Indicators: The number and size of cavities within snags of an AU cannot be measured directly because they can be difficult to see during a "rapid" site visit. Snag characteristics and decay classes can, however, be an estimate of the presence of cavities. Eight different categories of snags representing different levels of decay are used as the indicator for the different potential sizes of cavities. It is assumed that snags will be used and cavities formed or excavated if dead branches or trunks are present. In addition, more importance is given if at least one of the snag categories is larger than 30 cm dbh.

Scaling: A depressional closed AU with 6 or more of the 8 categories of snag characteristics are present is scored a [1]. Fewer categories are scaled as proportional to 6 (i.e. # of categories/6). If the AU has any snag that is larger than 30 cm dbh, the score for V_{snag} is increased by 0.3.

$V_{veginterspersp}$ – The extent of interspersion between Cowardin vegetation classes.

Rationale: The amount of interspersion between vegetation classes is a structural element of the wetland plant community that reflects habitat complexity. This is a measure of interspersion between classes, not a measure of the number of classes present. Consequently, an AU with only two Cowardin vegetation class types present may have a higher degree of interspersion than an AU with 3 Cowardin vegetation classes present.

In general, more "edge" between different vegetation community types increases the habitat suitability for some wildlife taxa. For example, a higher interspersion of plant types (as characterized by Cowardin vegetation classes) is likely to support a higher diversity of macro-invertebrates (Chapman 1966, Dvorak and Best 1982, and Lodge 1985).

Indicators: The amount of interspersion between vegetation classes is assessed using diagrams developed from those found in the Washington State Rating System (WDOE 1993).
Scaling: AUs with more interspersion between vegetation classes score higher than those with fewer. The model has four categories of interspersion (none, low, moderate, high) and these are used as the basis for developing a scaled score. A high level of interspersion is scored a 1, a moderate a 0.67, a low = 0.33, and none = 0.

V_{lwd} – The number of categories (size and decay) of downed large woody debris (size and decay level) in the AU. This consists of woody debris found floating or partially submerged in permanent open waters as well as that found in the vegetated parts of the AU.

Rationale: Woody debris provides a major habitat niche for decomposers and invertebrates. Is also provides refuge for amphibians and other vertebrates, and contribute to the production of organic soils. Downed woody material is an important structural element of habitat for many species. In the water, it is important for both resident and anadromous fish, as well as numerous amphibians. In upland areas of the AU it provides shelter for small mammals, birds, and amphibians (Thomas et al. 1978). The downed woody material is also an important structural element for invertebrate species that in turn provide food for much of the AU trophic webs (Maser et al. 1988).
Indicators: Direct measures of the quantity and quality of decaying woody debris is not feasible for a rapid assessment method. A descriptive matrix of different size classes and decay levels is used as an indicator for the variable. The matrix is based on the assessment procedure developed for the Timber Fish and Wildlife watershed assessment methods (Schuett-Hames et al. 1994).
Scaling: AUs with 10 or more categories of large woody debris in permanent open water and in vegetated areas score a [1]. The rest are scored proportionally to 10 (# categories /10).

V_{hydrop} – The number of different hydroperiods, or water regimes, present in the AU.

Rationale: Many aquatic species have their life cycles keyed to different water regimes of permanent, seasonal, or saturated conditions. A number of different water regimes in an AU will, therefore, support more species than an AU with fewer water regimes. For example, some species are tolerant permanent pools, while others can live in pools that are temporary (Wiggins et al. 1980).
Indicators: The variable is assessed using specific hydroperiod classes as descriptors. These are permanently flooded, seasonally flooded, occasionally flooded, and saturated but not flooded as described below.

Permanently Flooded or Inundated– Surface water covers the land surface throughout the year, in most years. This includes the Cowardin classes of **Intermittently Exposed (**surface water is present throughout the growing season except in years of extreme drought), and **Semipermanently Flooded** (surface water persists throughout the growing season in most years).
Seasonally Flooded or Inundated – Surface water is present for extended periods (1 month), especially early in the growing season, but is absent by the end of the season in most years. During the summer dry season it may be difficult to determine the area that is seasonally flooded. Use the indicators described in D8.1 to help you determine the area that is seasonally flooded or inundated.
Occasionally Flooded or Inundated – Surface water is present for brief periods during the growing season, but the water table usually lies below the soil surface for most of the season. Plants that grow in both uplands and wetlands are characteristic of the temporarily flooded regime.
Saturated – The substrate is saturated to the surface for extended periods during the growing season, **but surface water is seldom present**. The latter criterion separates saturated areas from inundated areas. In this case there will be no signs of inundation on plant stems or surface depressions.

Scaling: AUs with all four hydroperiod classes are scored a [1]. Those with fewer are scored proportionally (3 classes = 0.67, 2 = 0.33, 1 = 0).

$V_{waterdepth}$ – the number of water depth categories present in the AU in the permanent or seasonal inundated areas.

Rationale: Different water depths provide habitat for different plant communities (emergent vs. aquatic bed as examples) that in turn provide different habitat for waterfowl (Weller 1990), amphibians (Richter 1978), and other vertebrate taxa as well as invertebrates (Wilcox and Meeker 1992). A wetland with a range of water depths will therefore, provide a broader range of habitats than one with only one water depth.

Indicators: The variable is scored using a condensed form of the depth classes developed for the Wetland Evaluation Technique (Adamus et al. 1987). These are 0-20 cm, 21-100 cm, and >100 cm depth classes.

Scaling: AUs with all 3 depth classes are scored a [1]; those with 2 are scored [0.67]; 1 class = [0.33], and 0 classes = [0] .

$V_{wintersp}$ – The extent of interspersion between vegetated areas of the AU and permanent open water.

Rationale: The extent of water interspersed with vegetation is another structural element of the AU that can add habitat complexity. The complexity of the mosaic pattern of the interface between open water and vegetation is an indicator of more habitat niches being available.

High interspersion between vegetation and water is important because of the increased variety of vegetation types and cover conditions result from such interspersion (Adamus et al. 1991). Contact zones between open water and vegetation provide protection from wind, waves, and predators, and may provide natural territorial boundaries for wildlife (Golet and Larson 1974). The transition between water and vegetation also provide habitat elements for both open-water, and more terrestrial species (Weller and Spatcher 1965, and Willard 1977).

Indicators: The interspersion in an AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: AUs with high interspersion score a [1]; those with moderate are scored [0.67]; those with low = [0.33], and those with no interspersion (i.e. no permanent open water) = [0]

$V_{prichness}$ – The total number of plant species present.

Rationale: The number of plant species in an AU is an indicator of the potential number of niches present for insects, other invertebrates, and microfauna. Many insects and detritivores are associated with a specific plant species in a parasitic, commensal, or symbiotic relationship. The total number of wildlife species in an AU is expected to increase as the number of plant species increases. Plant species includes both native and non-natives because both provide food, cover and other habitat requirements for invertebrates.

Indicators: The indicator of overall plant richness is the number of species that is found during the field visit.

Scaling: Depressional closed AUs with 40 or more plant species are scored a [1]. Those with less are scored proportionally to 40 (# species/40). The assessment team recognizes that there may be some discrepancy between the number of species that can be identified in the summer and the number that can be identified in the winter.

V_{mature} – The AU has, or does not have, mature trees present.

Rationale: The presence of mature trees within an AU is used as an indicator of habitat richness that is not captured in other variables. Mature trees are an indication that the area within the AU has had time to develop a complex physical structure on its surface (e.g. large and small woody debris with different levels of decomposition, a range of vegetation in different growth stages from seedlings to senescent). These structural elements provide an increased number of niches for many organisms.

Indicators: This variable is characterized by measuring the dbh (diameter at breast height) of the five largest trees of each species. If the average diameter of the three largest of a given species exceed the diameters given in Part 2, the AU is considered to contain a stand of mature trees. See Part 2 for a more detailed description of how to assess this variable. The size of trees at maturity used in the data are based on measurements made in wetlands of the Puget Sound Lowlands (Cooke pers. comm.) and the judgement of the Assessment Team.

Scaling: This is an "on/off" variable. AUs with mature trees are scored a [1], those without are scored a [0].

$V_{edgestruc}$ – The vertical structure and linear characteristics of the AU edge.

Rationale: The convolutions (e.g., length of edge in relation to area of AU) and differences in heights of vegetation classes along the edge of the AU are important habitat characteristics for many wildlife species. Additional habitat exists within vegetated lobes and scalloped edges of wetlands. Further, embayments and peninsulas provide "micro-habitats" for certain species that require hiding cover, or visual isolation (USDI 1978, Verner et al. 1986, and WDOE 1993).

For example, a simple AU may be a circular pond with a fringing emergent marsh composed of cattails, which adjoins immediately to a grazed pasture. The edge in this case is characterized as having low structural richness (lack of shrubs and trees), and no convolutions (as the edge is nearly circular, with no embayments or peninsulas). In contrast, a more complex AU may adjoin an area composed of trees and shrubs, adding to the structural richness, and may be irregular along its edge, with many convolutions, resulting in enclosed bays of emergent vegetation and jutting peninsulas of forest or shrub.

Indicators: The edge structure of the AU is assessed by using a descriptive key that groups the edges and vertical structure along the edge into high, medium, low, and no structural diversity.

Scaling: AUs with a highly diverse edge are scored a [1]; moderate = 0.67, low = 0.33, and none = 0.

$\boldsymbol{V_{upcover}}$ – the types of land uses within 1 km of the estimated edge of the AU. **This variable is used to indicate potential reductions in the level of performance for the function.**

Rationale: It is assumed that development (land conversion) around an AU will alter the water regime of the AU by shortening the time between the event and the peak within the AU. This will increase rates of flows through the AU, increase peak flows, increase volumes of water, and decrease low-flow duration from storm-water runoff from converted landforms in the AU contributing basin. Increases in flow rates can increase export of nutrients from the AU, it often increases the input of sediments and nutrients, and it results in less stable water level conditions. Wetland invertebrates and plants are also known to decrease in richness and abundance with greater water level fluctuations and concomitant pollution loads (Ludwa 1994, Schueler 1994, Azous and Richter 1995, and Hicks 1995)

Indicators: The indicator for this variable is the % of the land within a 1 km radius of the AU that is in urban, residential, or clear cut.

Scaling: The index of general habitat suitability is reduced by 10% (factor of 0.9) if the land uses within 1 km total more than 60% high density residential, low density residential, urban/commercial or clear cut.

7.7.5 Calculation of Habitat Suitability

Depressional Closed – General Habitat Suitability

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 5	If D42 =5, enter "1"	
	High:	Buffer category of 4	If D42 =4, enter "0.8"	
	Moderate:	Buffer category of 3	If D42 =3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D42 =2, enter "0.4"	
	Low:	Buffer category of 1	If D42 =1, enter "0.2"	
	Lowest:	Buffer category of 0	If D42 =0, enter "0"	
V%closure	*Highest:*	Canopy closure is between 30-60%	If D17 > = 30 and D17 < = 60, enter "1"	
	Moderate:	Canopy closure is between 10-29% or 61-100%	If D17 = 10 to 29 or D17 = 61-100, enter "0.5"	
	Lowest:	Canopy closure is <10%	If D17 < 10, enter "0"	
Vstrata	*Highest:*	6 strata present	If D21 = 6, enter "1"	
	High:	5 strata present	If D21 = 5, enter "0.8"	
	Moderate:	4 strata present	If D21 = 4, enter "0.6"	
	Medium Low:	3 strata present	If D21 = 3, enter "0.4"	
	Low:	2 strata present	If D21 = 2, enter "0.2"	
	Lowest:	1 strata present	If D21 = 1, enter "0"	
Vsnags	*Highest:*	At least 6 categories of snags and some > 30 cm dbh	If D31 > = 6 and D31.1 =1, enter "1.3"	
	Lowest:	No snags present	If D31 = 0, enter "0"	
	Calculation:	Scaled as # categories/6 + 0.3 if dbh > 30 cm	Enter result of calculation	
	If D31 < 6 calculate D31/6 + (D31.1x 0.3) If D31 > 6 calculate 1 + (D31.1x0.3)			
Vvegintersp	*Highest:*	High interspersion	If D39 = 3, enter "1"	
	Moderate:	Moderate interspersion	If D39 = 2, enter "0.67"	
	Low:	Low interspersion	If D39 = 1, enter "0.33"	
	Lowest:	No interspersion (1 class only)	If D39 = 0, enter "0"	
Vlwd	*Highest:*	AU has at least 10 categ. of sizes and decomposition states of LWD	If calculation > = 1, enter "1"	
	Lowest:	No categories of LWD	If calculation = 0, enter "0"	
	Calculation:	Scaling based on #of categ. / 10	Enter result of calculation	
	Calculate (D44 + D45)/10 to get result			
Vhydrop	*Highest:*	AU has 4 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 4, enter "1"	
	High:	AU has 3 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 3, enter "0.67"	
	Moderate:	AU has 2 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 2, enter "0.33"	
	Low:	AU has 1 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 1, enter "0"	
				Table continued on next page
Vwaterdepth	*Highest:*	AU has 3 classes of depths	If D12.1 + D12.2 + D12.3 = 3, enter "1"	

Variable	Description of Scaling		Score for Variable	Result
	Moderate:	AU has 2 classes of depths	If D12.1 + D12.2 + D12.3 = 2, enter “0.67”	
	Low:	AU has 1 class of depths	If D12.1 + D12.2 + D12.3 = 1, enter “0.33”	
	Lowest:	AU has no surface inundation	If D12.1 + D12.2 + D12.3 = 0, enter “0”	
Vwintersp	*Highest:*	High interspersion	If D38 =3, enter “1”	
	Moderate:	Moderate interspersion	If D38 = 2, enter “0.67”	
	Low:	Low interspersion	If D38 = 1, enter “0.33”	
	Lowest:	No interspersion	If D38 = 0, enter “0”	
Vprichness	*Highest:*	Number of plant species > = 40	If calculation > = 1.0, enter “1”	
	Lowest:	AU has 2 or less plant species	If D19.1 + D19.2 < = 2, enter “0”	
	Calculation:	Scaled as # of species/40	Enter result of calculation	
	Calculate (D19.1 + D19.2)/40 to get result			
Vmature	*Highest:* *Lowest:*	AU has mature trees present AU has no mature trees present	If D22 = 1, enter “1” If D22 = 0, enter “0”	
Vedgestruc	*Highest:*	High structure at edge of AU	If D41 = 3, enter “1”	
	Moderate:	Moderate structure	If D41 =2, enter “0.67”	
	Low:	Low structure	If D41 =1, enter “0.33”	
	Lowest:	No structure	If D41 =0, enter “0”	
			Total of Variable Scores:	
Reducer				
Vupcover	If clear cutting, high or low-density residential, and urban land uses within 1 km are > = 60%.		If D3.3 + D3.4 + D3.5 + D3.6 > = 60, enter “0.9”	
	If critical land uses <60%		Enter “1”	
			Score for Reducer	
Index for General Habitat Suitability = Total for variables x reducer x 0.93 rounded to nearest 1				
			FINAL RESULT:	

7.7.6 Qualitative Rating of Opportunity

The land-use patterns within the upland buffer and surrounding landscape influences the opportunity that an AU has to provide general habitat. Connectivity of AUs to other protected areas affects specific use of the habitat within the AU by species, in particular those species whose life history needs include a large range of landscape types (e.g., the larger predators, raptors, etc.). For some populations, the connectivity between wetland habitats may be crucial to the survivability of the population.

The opportunity that an AU has to provide habitat for a broad range of species should be judged by characterizing the landscape in which an AU is found. An AU may have many internal structural elements that indicate it provides good habitat. Its landscape position, however, may reduce the actual performance because it is not accessible to the populations that would use it.

Users must make a qualitative judgement on the opportunity the AU has in providing habitat for a broad range of species by considering the land uses in the contributing watershed, the condition of the AU's buffer, and its connection to other habitat areas. Two data on the data sheets can be used to help guide your judgement (D43 on corridors and D42 on buffers).

In general, the opportunity for an AU in the depressional closed subclass to provide habitat is **"High"** if it has extensive natural buffers and forested or riparian corridors to other habitats. Other habitats may include undisturbed grasslands, open water, shrubs, or forested areas. The opportunity is **"Moderate"** if the AU has some connections to other habitat areas or less extensive undisturbed buffers. It is **"Low"** if the AU is surrounded by development and has no naturally vegetated corridors to other habitat areas.

User's must use their judgement in deciding whether the opportunity is low, moderate, or high, and document their decision on the data sheet.

7.8 Habitat Suitability for Invertebrates — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.8.1 Definition and Description of Function

Habitat Suitability for Invertebrates is defined as the wetland characteristics that help maintain a high number of invertebrate species in the wetland. The term invertebrates is here more narrowly defined as "macro-invertebrates" or free-living organisms readily seen with the naked eye (>200-500 um). This includes among others: Insecta (insects), Amphipoda (scuds, sideswimmers), Eubranchiopoda (fairy, tadpole, and clam shrimps) Decapoda (crayfishes, shrimps), Gastropoda (snails, limpets), Pelecypoda (clams, mussels), Hydracarina (water mites), Arachnida (spiders) and Annelida (worms and leeches).

The intent of the assessment is to identify those wetlands that provide habitat for the greatest number of invertebrate species within the regional subclass. Invertebrates are diverse, abundant, and essential components of freshwater aquatic ecosystems. Almost any AU will provide a habitat for some invertebrates. There is a distinct difference, however, between an AU that has a high abundance of one or two species and one that has a high richness of many different species. The important aspect of invertebrate populations that is being assessed is species richness. Wetlands with a high richness tend to be more important in maintaining the regional biodiversity of invertebrate populations and by providing genetic diversity that helps maintain ecosystem integrity.

Invertebrates have evolved unique adaptations to enable them to occupy most wetland habitats and trophic levels. Consequently, wetland invertebrates are pivotal components of complex food webs, significantly increasing the number of links with the rich diversity and abundance of their taxa. As filter feeders, shredders and scrapers, insects convert and assimilate microorganisms and vegetation into biomass providing significant production that then becomes available to secondary and tertiary consumers. Recent research focusing on aquatic invertebrates in wetlands indicates the importance of macro-invertebrates in energy and nutrient transfer within aquatic ecosystems (Rosenberg and Danks 1987). They furnish food for other invertebrates and comprise significant portions of the nutritional requirements of amphibians, water birds, and small mammals. They are an especially important food source for young fish (e.g., salmonids, and game fish). The trophic diversity and numerical abundance of insects, and especially Diptera (true flies), make these taxa one of the most important in wetland environments.

In addition, macro-invertebrates have been used as bioindicators of the health of streams and lakes (Rosenberg and Resh 1996), and increasingly of wetlands (Hicks 1996); their taxa and numbers indicating conditions of hydrodynamics, hydrology, soils, vegetation, eutrophication, and anthropogenic pollution.

7.8.2 Assessing this Function for Depressional Closed Wetlands

The habitat suitability of depressional closed wetlands for a highly diverse assemblage of invertebrates is assessed by characterizing the complexity of the biologic and physical structures of the AU. The model is built on the assumption that almost any structure in the AU (i.e. channels, ponds, upland/AU edge, etc.) or plant association hosts a specialized invertebrate community. The operative assumption is that the richness of invertebrate species increases as the number of structural characteristics in an AU increase.
Certain conditions present in an AU, however, are considered to be detrimental to invertebrates and these are modeled as reducers of the performance. The presence of tannins is considered to reduce the performance of a AU as invertebrate habitat because many species are sensitive to the organic acids present in tannins.

7.8.3 Model at a Glance

Depressional Closed — Habitat Suitability for Invertebrates

Characteristics	Variables	Measures or Indicators
Number of habitat niches for invertebrates (applies to all variables)	**Vsubstrate**	Types of surface substrates present
	Vwintersp	Characteristics of water interspersion - diagrams
	Vlwd	Categories of LWD present
	Vstrata	Number of strata present in any plant association
	Vvegintersp	Interspersion between vegetation classes -diagrams
	Vassemb	Number of plant associations
	Vhydrop	Number of water regimes
	Vaquastruc	Categories of different aquatic bed structures
Reducers		
	Vtannins	Qualitative estimate of presence/absence of tannins

Index:

$$\frac{(\text{Vsubstrate} + \text{Vwintersp} + \text{Vlwd} + \text{Vstrata} + \text{Vvegintersp} + \text{Vassemb} + \text{Vhydrop} + \text{Vaquastruc}) \times (\text{Vtannins})}{\text{Score for reference standard site}}$$

7.8.4 Description and Scaling of Variables

***V**$_{substrate}$* **–** The composition of surface layers present in the AU (litter, mineral, organic etc).

Rationale: Not much is known about invertebrate distributions in different substrates within a wetland. Data from rivers, streams, and lakes, however, show that the local invertebrate species have preferences for specific substrate (Dougherty and Morgan 1991, and Gorman and Karr 1978). In streams it is well known that Chironomid community composition is strongly affected by sediment characteristics (McGarrigle 1980, and Minshall 1984). The Assessment Teams assumed that a similar relationship between invertebrate populations and substrates is also found in wetlands. Thus, AUs with different substrates present will provide habitat for a broader group of invertebrate species than those with only one type. Moreover, those with organic matter will exhibit greater richness and abundance than those found in sand substrates.

Indicators: No indicators are needed to assess this variable. The number of different substrate types can be determined by direct field observations.

Scaling: AUs with five or more types of substrates of the eight identified (deciduous leaf litter, other plant litter, decomposed organic, exposed cobbles, exposed gravel, exposed sand, exposed silt, exposed clay) are scored a [1]. Those with fewer are scaled proportionally (# types/5). AUs with no soil surface exposed (e.g. sphagnum bog) are scored a [0].

***V**$_{wintersp}$* **–** The amount of interspersion present between vegetated portions of AU and permanent open water.

Rationale: The amount of interspersion between permanent open water and vegetation is another structural element of the AU that can add habitat complexity. Studies have shown that high invertebrate richness occurs in water interspersed with stands of emergent vegetation (Voigts 1976).

Indicators: The interspersion in an AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none.

Scaling: Depressional closed AUs with high interspersion score a [1]; those with moderate are scored [0.67]; those with low = [0.33]; and those with no interspersion (i.e. no permanent open water) = [0].

***V**$_{lwd}$* – The number of categories, based on size and level of decay, of fallen large woody debris (LWD) in permanent open water and on the vegetated surface of the AU. The categories are based on the Timber, Fish, and Wildlife rating criteria (Schuett-Hames et al. 1994).

Rationale: Downed woody material is an important structural element for invertebrate species. Decaying wood provides an important habitat for invertebrates (Maser et al. 1988). The Assessment Teams assumed that downed debris of different size and different levels of decay classes would provide habitat for a wide variety of invertebrates, especially those that decompose, feed, and seek shelter in wood.

Indicators: Direct measures of the quantity and quality of decaying woody debris is not feasible for a rapid assessment method. Consequently, a descriptive matrix of different sizes and decay classes of woody debris was developed as an indicator for the variable. The matrix is based on the assessment procedure developed for the TFW watershed assessment methods.

Scaling: AUs with 10 (out of 24 possible) or more categories of LWD in open water and on the surface are scored a [1]. Those with less are scaled proportionally (# categories/10).

***V**$_{strata}$* **–** The number of vegetation strata in any single plant assemblage. A plant assemblage can have up to 6 strata (layers: trees, high shrubs, low shrubs, woody vine, herbaceous, moss). To count as a stratum, however, the plants of that stratum have to have 20% cover in the association in which it is found.

Rationale: Different invertebrate taxa are found on different plant species (Cyr and Downing 1988). The vegetation strata are used as an indicator of distinct groups of plant species that might have specific ecological characteristics to which invertebrate taxa might be adapted.

Indicators: No indicators are needed for this variable. The number of strata present in any single plant assemblage can be determined by direct field observations.

Scaling: AUs with 6 strata are scored a [1] for this variable. AUs with only one are scored a [0]. AUs with 2-5 strata are scaled proportionally as 0.2, 0.4, 0.6, and 0.8, respectively.

***V**$_{veginterp}$* – The extent of interspersion between Cowardin vegetation classes.

Rationale: The extent of interspersion between vegetation class is a structural element of the plant community in an AU that reflects on habitat complexity. A higher diversity of plant communities (as characterized by Cowardin vegetation classes) is likely to support a higher diversity of macro-invertebrates (Chapman 1966, Dvorak and Best 1982, Lodge 1985).

Indicators: The extent of interspersion between vegetation classes is assessed using diagrams found in the Washington State Rating System (WDOE 1993).

Scaling: AUs with more interspersion between vegetation classes score higher than those with fewer. The method has four categories of interspersion (none, low, moderate, high) and these are used as the basis for developing the scaled score. A high level of interspersion is scored a 1, a moderate = 0.67, a low = 0.33, and none = 0.

V_{assemb} – The number of distinct plant assemblages found within the AU.

Rationale: A mixture of plant assemblages exhibits a greater diversity and biomass of invertebrates than does a single one within an area (Andrews and Hasler 1943). For example, the standing crop of invertebrates varies considerably among different species of submerged aquatic macrophytes (Murkin and Batt 1987), and different epiphytic invertebrate taxa are found on different plant species (Cyr and Downing 1988.)

Indicators: No indicators are needed to assess this variable. The number of associations can be determined through field observations.

Scaling: Depressional closed AUs with 6 or more plant associations are scored a [1]. AUs with fewer are scaled proportionally.

V_{hydrop} – The number of different water regimes present in the AU.

Rationale: Many lentic invertebrates have their life cycles keyed to different water regimes. A diversity of water regimes in an AU will, therefore, support more species than an AU with a less diverse water regimes. For example, some species are characteristics of permanent pools while other live in pools that are strictly temporary (Wiggins et al. 1980).

Indicators: The variable is assessed using four hydroperiod classes as descriptors. These are permanently flooded, seasonally flooded, saturated, occasionally flooded. See detailed description in Section 6.7.4.

Scaling: AUs with four hydroperiod classes are scored a [1]. Those with fewer are scored proportionally (3 classes = 0.67, 2 = 0.33, 1 = 0).

$V_{aquatstruc}$ – The number of different types of plant structures present in aquatic bed vegetation.

Rationale: Different types of aquatic bed vegetation provide different structure, and consequently, different niches for invertebrates (Wilcox and Meeker 1992). Thus, species richness increases as the structural diversity of aquatic bed vegetation increases.

Indicators: This variable is quantified using a diagram showing different types of structures found in aquatic bed vegetation.

Scaling: AUs with all three types of structure present score a [1]. Those with 2 score a [0.67]; those with 1 score [0.33]; and those with none score a [0].

$V_{tannins}$ – The concentration of tannins present in water. This variable is used to indicate potential reductions in the level of performance for the function.

Rationale: Tannins occur in undisturbed systems and may be limiting to invertebrates. For example, in Atlantic Canada isopods are presumed absent from ponds because they are humic (i.e. have tannins in them) (Walker et al. 1985).

Indicators: The presence of clear, brown, water in an AU (i.e. brown without any sediment or particulate matter) will be used as the indicator that tannins are present in sufficient concentrations to deter their use by invertebrates or to impair their growth. A more detailed description of how to characterize concentrations of tannins is found in Part 2.

Scaling: This is an "on/off" variable that results in a reduction in the overall index. AUs with tannins present have their index reduced by a factor of 0.7.

7.8.5 Calculation of Habitat Suitability

Depressional Closed – Habitat Suitability for Invertebrates

Variable	Description of Scaling		Score for Variable	Result
Vsubstrate	*Highest:*	5 categories of surface layers	If calculation is > = 1, enter "1"	
	Lowest	AU has no solid surface exposed	If calculation = 0, enter "0"	
	Calculation:	Scaling based on number of categories of surface layers/5	Enter result of calculation	
	Calculate sum (D46.1 – D46.8)]/5 to get result			
Vwintersp	*Highest:*	High interspersion between land and water	If D38 = 3, enter "1"	
	Moderate:	Moderate interspersion	If D38 = 2, enter "0.67"	
	Low:	Low interspersion	If D38 = 1, enter "0.33"	
	Lowest:	no interspersion	If D38 = 0, enter "0"	
Vlwd	*Highest*	AU has at least 10 categories of different sizes and decomposition states of large woody debris	If calculation > = 1, enter "1"	
	Lowest:	No categories of LWD	If calculation = 0, enter "0"	
	Calculation:	Scaling based on the number of categories divided by 10	Enter result of calculation	
	Calculate (D44 + D45)/10 to get result			
Vstrata	*Highest:*	6 strata present	If D21 = 6, enter "1"	
	High:	5 strata present	If D21 = 5, enter "0.8"	
	Moderate:	4 strata present	If D21 = 4, enter "0.6"	
	Medium Low:	3 strata present	If D21 = 3, enter "0.4"	
	Low:	2 strata present	If D21 = 2, enter "0.2"	
	Lowest:	1 strata present	If D21 = 1, enter "0"	
Vvegintersp	*Highest:*	High interspersion between vegetation classes	If D39 = 3, enter "1"	
	Moderate:	Moderate interspersion	If D39 = 2, enter "0.67"	
	Low:	Low interspersion	If D39 = 1, enter "0.33"	
	Lowest:	AU has no interspersion (1 class only)	If D39 = 0, enter "0"	
Vassemb	*Highest:*	AU has at least 6 plant assemblages	If calculation > = 1, enter "1"	
	Lowest:	AU has 1 plant assemblage	If D20 = 1, enter "0"	
	Calculation:	Scaling is based on the number of assemblages divided by 6	Enter result of calculation	
	Calculate (D20-1)/5 to get result			
Vhydrop	*Highest:*	AU has 4 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 4, enter "1"	
	Moderate:	AU has 3 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 3, enter "0.67"	
	Low:	AU has 2 water regimes present	If D9.1 + D9.2 + D9.3 + D9.4 = 2, enter "0.33"	
	Lowest:	AU has 1 water regime present	If D9.1 + D9.2 + D9.3 + D9.4 = 1, enter "0"	
				Table continued on next page
Vaquastruc	*Highest*	AU has 3 structures of aquatic bed vegetation	If D25 = 3, enter "1"	

Variable	Description of Scaling		Score for Variable	Result
	High:	AU has 2 structures of aquatic bed vegetation	If D25 = 2, enter “0.67”	
	Moderate:	AU has 1 structures of aquatic bed vegetation	If D25 = 1, enter “0.33”	
	Lowest:	AU has 0 structures of aquatic bed vegetation	If D25 = 0, enter “0”	
			Total of Variable Scores:	
Reducer				
Vtannins	AU has tannins present		If D36 =1, enter “0.7”	
	AU has no tannins present		If D36 = 0, enter “1”	
			Score for Reducer	
Index for Habitat Suitability for Invertebrates = Total for variables x reducer x 1.39 rounded to nearest 1				
			FINAL RESULT:	

7.9 Habitat Suitability for Amphibians — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.9.1 Definition and Description of Function

Habitat Suitability for Amphibians is defined as the wetland characteristics that contribute to the feeding, breeding, or refuge needs of amphibian species. Amphibians in the lowlands of western Washington are a vertebrate group that include wetland-breeding frogs and toads (e.g., Order Anura, tailless amphibians except as larvae) and salamanders and newts (e.g., Order Caudata (Uradela) tailed amphibians). Their richness and abundance indicates they are extremely important in wetland trophic organization. Many native species only breed for a short time in wetlands and live in uplands as metamorphosed juveniles and adults (Richter 1997). Some species may be found in or close to wetlands throughout the year. Eggs and larvae of wetland breeding species, however, require free water for development.

Wetlands play an important role in the life cycles of amphibians by providing the quiet waters, shelter, and food sources needed for the early stages of amphibian development. The suitability of an AU as amphibian habitat is assessed by characterizing the conditions in a wetland that enable spawning, support the development of eggs and larvae, and provide protection and food for larvae in addition to adults moving in and out of the wetland.

In general, the suitability of an AU as amphibian habitat increases as the number of the appropriate habitat characteristics increase for all life stages. **The assessment model is focused on species richness and conditions that would support many different species, not on the importance of a wetland to a specific threatened or endangered species.**

If the wetland is a habitat type that appears to be critical to a specific species, another method is needed to better determine the habitat suitability of that wetland.

7.9.2 Assessing this Function for Depressional Closed Wetlands

The suitability of an AU in the depressional closed subclass as habitat for amphibians is modeled on the different types of physical and biologic characteristics present that have been shown to be important for the survival of amphibians.

Not all important wetland characteristics, however, could be assessed. For example, water level fluctuations are known to be important (Richter and Azous 1995, Azous and Richter 1995, and Richter 1997), but could not be characterized adequately in one site visit. Another variable known to be critical to amphibians in wetlands is the presence of corridors to other wetlands or to upland habitats. The presence of relatively undisturbed migration routes between the AU and upland feeding and hibernation sites are an important habitat element for many amphibian species (Heusser 1968, Berven and Grudzien 1990, Beebee 1996). Moreover, dispersal routes from source populations are critical when populations are eliminated by stochastic processes including drought (Pounds and Crump 1994), disease (Bradford 1991), pollution (Richter pers. obs.), or when populations produce insufficient offspring to permanently occupy a site (Gill 1978a, b; and Sinsch 1992). Finally, amphibians within an AU benefit as members of a metapopulation extending across several wetlands by maintaining healthy populations that otherwise may go extinct from inbreeding depression (Sofgren 1991, 1994, and Pechmann and Wilbur 1994).

Unfortunately, the information required to adequately assess the presence and suitability of corridors for amphibians proved to be too complex for a rapid assessment method. The data that can be collected from maps and aerial photos does not provide the resolution needed to adequately represent the needs of amphibians. Corridors need to be assessed on site, and the access to them may not be possible.

Two variables included (V_{phow} and $V_{upcover}$) reflect the potential for a reduction in the performance of this function. Acidic water will impair egg and larval development (Sadinski and Dunson 1992, and Rowe et al. 1992). Furthermore, natural habitats in the surrounding uplands are considered to be of paramount importance for maintaining viable amphibian populations (Semlitsch 1981, Kleeberger and Werner 1983, Bury and Corn 1988, and Dupuis et al. 1995). The absence of relatively undisturbed vegetation is modeled as a reduction in suitability of the wetland itself because it is a necessary condition if the wetland is to provide a suitable habitat for amphibians.

The Assessment Teams considered using the presence of fish and bullfrogs as a reducer of habitat suitability because both of these predators are known to prey on native amphibians. However, the presence of these species cannot always be determined during a single site visit. Users of the method are encouraged, however, to record the presence of either fish or bullfrogs in their report. If either predator is present, the index that is calculated by the assessment model may not reflect the actual habitat suitability of the AU.

7.9.3 Model at a Glance

Depressional Closed — Habitat Suitability for Amphibians

Process	Variables	Measures or Indicators
Breeding, feeding, and refuge for amphibians (applies to all variables)	**Vbuffcond**	Descriptive table of conditions in buffer
	Vsubstrate	Types of surface substrates present
	Vwintersp	Diagrams
	Vlwd	Categories of LWD present
	Vwater	% of AU with permanent water, or permanent water under FO or SS
	Vsubstruc	Categorization by dichotomous key
Reducers		
	Vphow	pH tabs, direct measurement
	Vupcover	Land uses within 1 km of wetland
	Index:	(Vbuffcond + Vsubstrate + Vwintersp + Vlwd + Vwater + Vsubstruc) x (Vphow or Vupcover) / Score for reference standard site

7.9.4 Description and Scaling of Variables

$V_{buffcond}$ – Condition of buffer within 100 m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: Conditions in the buffers of an AU are especially important in providing cover to amphibian females and to newly metamorphed animals. Female *R. aurora*, *A. gracile* (Richter pers. obs.), and *A. macrodactylum* (Beneski et. al. 1986, and Leonard and Richter 1994) generally wait in buffers near wetlands until environmental and biological conditions are favorable to spawning. They then enter wetlands during one or a few nights to spawn, thereafter quickly retreating to cover of buffers. Metamorphs of most species also benefit from wetland buffers. They are important to the tiger salamander (*A. tigrinum*) seeking shelter in rodent burrows during the first days following emigration from natal ponds (Loredo et al. 1996). Metamorphs of *P. regilla*, *B. boreas R. aurora* and *T. granulosa* may spend several weeks in buffers prior to dispersing upland if soil and vegetation is dry beyond the buffer (Richter pers. obs.). Vulnerable metamorphs and juveniles have moisture, cover, and abundant invertebrate prey within forested wetland buffers.

Indicators: This variable is determined using a buffer categorization developed from the Washington State Rating System (WDOE 1993) (see data sheets Part. 2).

Scaling: Buffer categories are scaled as follows: category 5 = 1, category 4 = 0.8, category 3 = 0.6, category 2 = 0.4, category 1 = 0.2, category 0 = 0.

$V_{substrate}$ – The composition and types of surface layers present in the AU (litter, mineral, organic etc).

Rationale: Organic matter and leaf litter are important to larval amphibians as substrates for the zooplankton, phytoplankton, algae, and invertebrates that provide their food. Moreover, structural diversity in the form of leaf litter and woody debris provides shelter from weather and cover from predation. Different types of substrates provide niches for different invertebrate communities and thereby increase the richness of potential food sources.

Indicators: No indicators are needed to assess this variable. The substrate types can be determined by direct field observations.

Scaling: Scaling is based on the total number of different types of substrate present in the AU. Organic substrates, however, are given more importance (by a factor of two) because of their additional role as shelter. AUs with 3 categories of organic litter and 2 categories of inorganic surface types are scored a 1. Those with fewer are scaled proportionally (see Calculation Table 7.9.5).

***$V_{wintersp}$* –** The extent of interspersion present between vegetated portions of the AU and permanent open water.

Rationale: Most species of amphibians generally avoid both open water and densely vegetated sites, instead selecting habitats with an interspersion of both features (Strijbosch 1979, Ildos and Ancona 1994, Richter and Roughgarden in preparation, and Richter pers. obs.). Quantitative comparisons of vegetation cover surrounding *A. gracile* eggs suggest dense (95-100%) and light (0-5 %) cover is avoided (Richter and Roughgarden in preparation). Research findings suggest that for most species an interspersion between open water and vegetation is selected for oviposition. A 25-75 or 75-25 ratio of open water to vegetation may, therefore, be considered optimum for spawning.

Indicators: The extent of interspersion in a wetland is characterized by using a series of diagrams that rate interspersion into high, medium and low. Diagrams are based on those used in Wetland Evaluation Technique (Adamus et al. 1987, p.56) and in the Western Washington Rating Systems (WDOE 1993).

Scaling: Depressional closed AUs with high interspersion are score a [1]; those with moderate are scored [0.67]; those with low = [0.33], and those with no interspersion (i.e. no permanent open water) = [0] .

***V_{lwd}* –** The number of categories, based on size and level of decay, of fallen large woody debris (LWD) in the permanent open water and on the vegetated surface of the AU. The categories are based on the Timber, Fish, and Wildlife rating criteria (Schuett-Hames et al. 1994).

Rationale: There is no clear documentation of the quantity and type of large woody debris that is of benefit to amphibians in wetlands. However, tadpoles of western toads (*Bufo boreas*) frequently rest attached to large floating logs (Richter pers. obs.). Large woody debris in water most likely is important also as cover for larvae and adults, and as attachment sites for the algae and invertebrates that provide food.

Indicators: Direct measures of the quantity and quality of decaying woody debris is not feasible for a rapid assessment method. A descriptive matrix of different sizes and decay classes of woody debris was developed as an indicator for the variable. The matrix is based on the assessment procedure developed for the TFW watershed assessment methods.

Scaling: AUs with 10 (out of 24 possible) or more categories of LWD in open water and on the surface are scored a [1]. Those with less are scaled proportionally (# categories/10).

***V_{water}* –** The percent of the AU with permanent open water, aquatic bed vegetation, and areas of permanent standing water under a canopy of trees or shrubs.

Rationale: The extent of water without emergent vegetation is used as a surrogate for water level fluctuations. The assumption is that AUs with some open or standing water have lower water level fluctuations during the breeding season. Attempts were made to characterize water level fluctuations during the field calibration, but it was impossible to estimate the fluctuations that actually occur during the breeding season. The presence of open water is used as an indicator that water is present during the breeding season and that fluctuations will be lower than if no permanent water is present.

Most species of amphibians in temperate climates minimize exposure of eggs to fluctuating depths and temperatures by both spawning in mid-depth water and by submerging eggs below the surface (Richter 1997). Amphibian egg development also depends on permanent or partial submergence, and, therefore, optimum habitat conditions are those where water levels are stabilized from spawning through hatching. In most Puget Sound species this is from mid-December through mid-May. Although mean water level fluctuations exceeding 20 cm have been correlated to decreased amphibian richness in wetlands (Azous and Richter 1995) experiments suggest that extended drops of more than 7 cm from oviposition through hatching may harm *A. gracile*. Moreover, eggs of *A. macrodactylum* and *P. regilla* spawned in shallow water are harmed by stranding and desiccation on shore if water level fluctuations are severe.

Indicators: The percent of the AU that is in permanent open water or in aquatic bed vegetation can be estimated during the site visit. The presence of permanent standing water under a canopy of trees or shrubs is characterized only as present/absent.

Scaling:

	Score		
Highest	AU has at least 50% open water (Permanent Open water + aquatic bed)	1
High	AU has 10- 49% open water	0.8
Moderate	AU has no open water, but has permanent water under SS or FO or EM	0.5
Low	AU has 1-9% open water	0.2
Lowest	AU has **no** open water, or permanent water under SS or FO or EM	0

***V**$_{substruc}$* – A characterization of plant structures present under the water surface.

Rationale: Northwest caudates attach their eggs directly to vegetation within the water column (Slater 1936, Anderson 1967, Richter 1997 and references therein). Anurans anchor eggs to vegetation either below or near the surface (e.g. *R. aurora*, *B. boreas*) or occasionally spawn free-floating eggs (*R. pretiosa*; Licht 1969).

Experimental evidence suggests that vegetation structure, particularly plant shape and stem diameter are the oviposition criteria most important to caudates. Wetland surveys and controlled field studies of several northwest salamanders confirm that distinct stem widths are preferred by ovipositing caudates (Richter 1997). From these surveys and studies it can be inferred that species of submerged vegetation are unimportant for oviposition. Rather, the important factor is the size and structure of submerged vegetation.

Underwater structure is also important as a source of diversity in the food source. It provides a substrate for invertebrates and algae.

Indicators: This variable is determined by using a descriptive key outlining different categories of underwater structures for egg laying (see data sheets in Part 2 for key). The key rates the structures on a scale of 0-4.

Scaling: AUs with a rating of 4 in the key are scored a 1; those with a rating of 3 are scored a 0.75; rating of 2 = 0.5; rating of 1 = 0.25; and rating of 0 = 0.

***V**$_{phow}$* **–** The pH of open surface water in the AU. This variable is used to indicate potential reductions in the level of performance for the function.

Rationale: Acidic waters impair egg and larval development of Pacific Northwest amphibians. Hence they are generally absent from wetlands with a pH in its surface waters of 4.5 or less (Richter unpub. data).

Indicators: No indicators are needed. The pH of surface water can be measured directly using pH strips.

Scaling: AUs with a pH of 4.5 or less are assigned an index of [0] for the function. Those with a pH >4.5 but < 5.5 have their index reduced by a factor of 0.5. AUs with a pH of 5.5 or greater do not have their score reduced.

***V**$_{upcover}$* – The types of land uses within 1 km of the estimated AU edge. This variable is used to indicate potential reductions in the level of performance for the function.

Rationale: Wetlands that provide full range of biological processes of consequence to amphibians are located in relatively undeveloped areas (Schueler 1994, and Azous and Richter1995). Development increases water discharges, current velocities, and water level fluctuations in the AU. These environmental conditions diminish suitable amphibian breeding, feeding, and rearing habitat.

Moreover, wetland invertebrates and plants are also known to decrease in richness and abundance with greater water level fluctuations and concomitant pollution loads (Schueler 1994, Ludwa 1994, Azous and Richter 1995, and Hicks 1995) further reducing the quality of amphibian habitat in the AU.

Indicators: No indicators are needed to assess this variable. The amount and type of land uses within 1 km of the wetland can be established from aerial photographs or site visits.

Scaling: AUs with at least 60% of their surrounding land in urban or high density residential use have their index for the function reduced by a factor of 0.5. Those with at least 50% in clear-cut are also reduced by 0.5. AUs with at least 30% of their surrounding areas in any active land use (residential, urban, clear-cut, or agriculture) have their index reduced by a factor of 0.8.

7.9.5 Calculation of Habitat Suitability

Depressional Closed – Habitat Suitability for Amphibians

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 5	If D42 = 5, enter "1"	
	High:	Buffer category of 4	If D42 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D42 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D42 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D42 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D42 = 0, enter "0"	
Vsubstrate	*Highest:*	3 categories of organic litter + 2 inorganic surface layers	If D46.1 + D46.2 + D46.3 =3 and sum (D46.4 to D46.8) > = 2, enter "1"	
	Lowest:	AU has no ground surface exposed	If sum (D46.1-D46.8) = 0, enter "0"	
	Calculation:	Scaling is based on the number of categories of surface layers present; with organic surface layers weighted by a factor of two.	Enter result of calculation	
	If sum (D46.4 - D46.8) > = 2 calculate [(D46.1 + D46.2 + D46.3) x 2 + 1]/8; if sum (D46.4 - D46.8) < = 1 calculate [(D46.1 + D46.2 + D46.3) x 2 + sum (D46.4 - D46.8)]/8			
Vwintersp	*Highest:*	High interspersion between land and water	If D38 = 3, enter "1"	
	Moderate:	Moderate interspersion	If D38 = 2, enter "0.67"	
	Low:	Low interspersion	If D38 = 1, enter "0.33"	
	Lowest:	No interspersion	If D38 = 0, enter "0"	
Vlwd	*Highest:*	AU has at least 10 size categories and decomposition states of LWD	If calculation > = 1, enter "1"	
	Lowest:	No categories of LWD	If calculation = 0, enter "0"	
	Calculation:	Scaling based on the number of categories divided by 10	Enter result of calculation	
	Calculate (D44 + D45)/10 to get result			
Vwater	*Highest:*	AU has at least 50% exposed water (POW +AB)	If D8.3 + D14.6 > = 50, enter "1"	
	High:	AU has 10- 49% exposed water	If D8.3 + D14.6 > = 10 and < 50, enter "0.8"	
	Moderate:	AU has no exposed water, but has permanent water in SS, FO or EM	If D8.3 + D14.6 = 0 and D9.1 = 1, enter "0.5"	
	Low:	AU has 1-9% exposed water	If D8.3 + D14.6 > = 1 and < 10, enter "0.2"	
	Lowest:	AU has no water, or permanent water under SS or FO or EM	If D8.3 + D14.6 = 0 and D9.1 = 0, enter "0"	
			Table continued on next page	

Variable	Description of Scaling		Score for Variable	Result
Vsubstruc	*Highest:*	Score of 4 on underwater structures for egg laying	If D35 = 4, enter "1"	
	High:	Score of 3 on underwater structures for egg laying	If D35 = 3, enter "0.75"	
	Moderate:	Score of 2 on underwater structures for egg laying	If D35 = 2, enter "0.5"	
	Low:	Score of 1 on underwater structures for egg laying	If D35 = 1, enter "0.25"	
	Lowest:	Score of 0 on underwater structures for egg laying	If D35 = 0, enter "0"	
			Total of Variable Scores:	
Reducer				
Vphow	pH of standing water < 4.5		If D26.2 < = 4.5, enter "0"	
	pH of standing water >4.5 and < 5.5		If D26.2 > 4.5 and < 5.5, enter "0.5"	
	pH of standing water > =5.5		If D26.2 > = 5.5, enter "0.8"	
Vupcover	AU has > + 60% urban or high density residential land use; OR > = 50% clear cut within 1 km		If D3.4 + D3.5 > = 60 **OR** D3.3 > = 50, enter "0.5"	
	AU has as least 30% of area within 1 km in active land uses		If sum (D3.2-D3.6) > = 30, enter "0.8"	
	AU has less than 30% of area within 1 km in active land uses		If sum (D3.2-D3.6) < 30, enter "1"	
			Score for Reducer (Choose Lowest Value)	
Index for Amphibians = Total for variables x reducer x 1.72 rounded to nearest 1				
			FINAL RESULT:	

7.10 Habitat Suitability for Wetland Associated Birds — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.10.1 Definition and Description of Function

Habitat Suitability for Wetland-associated birds is defined as the environmental characteristics in a wetland that provide habitats or life resources for species of wetland-associated birds. Wetland-associated bird species are those that depend on aspects of the wetland ecosystem for some part of their life needs: food, shelter, breeding, and resting. The guilds of wetland associated birds used as the basis for building the assessment model includes waterfowl, shorebirds, and herons.

In general, the suitability of an AU as bird habitat increases as the number of appropriate habitat characteristics increase. Another assumption used in developing the model is that AUs that provide habitat for the greater number of wetland dependent bird species are scored higher than those that have fewer. **The assessment models are focused on species richness, not on the importance of a wetland to a specific threatened or endangered species or to a specific regionally important guild.**

If the AU is a habitat type that appears to be critical to a specific species, another method is needed in order to determine the habitat suitability of that AU (e.g. USFWS Habitat Evaluation Procedures (HEP), USFWS 1981).

7.10.2 Assessing this Function for Depressional Closed Wetlands

The suitability of wetlands in the depressional closed subclass as habitat for wetland-associated birds is modeled based on the plant structure, physical components, and the condition of the buffers around the AU. In addition, the models include the indices for other habitat functions that represent food for birds: namely the habitat suitability index for amphibians, invertebrates, and fish.

AUs that have a closed canopy are judged to have a reduced level of performance because access for waterfowl is limited. The Assessment Teams also judged that the presence of invasive or non-native birds may reduce the suitability of an AU. A variable for this factor was not included in the model because reproducible data on invasive or non-native birds could not be collected during one site visit.

Size is not used as a variable in the equation although it is often cited as an important characteristic of wetlands that provide bird habitat (Richter and Azous in preparation). The question of size is a vexing one, and no satisfactory size thresholds have been identified in the literature that would define the importance of a small versus a large wetland as habitat specific to only wetland-associated birds. Size, however, is incorporated indirectly in the scaling of some of the other variables used. Thus, it is implicit that an AU with a diverse structure is large—small AUs simply cannot contain the same number of different structural elements as large ones.

7.10.3 Model at a Glance

Depressional Closed — Habitat Suitability for Wetland-associated Birds

Characteristics	Variables	Measures or Indicators
Feeding, breeding, and refuge for wetland – associated birds (applies to all variables)	**Vbuffcond**	Descriptive table of conditions in buffer
	Vsnags	Categories of snags present
	Vvegintersp	Characteristics of interspersion between vegetation classes - diagrams
	Vedgestruc	Characteristics of AU edge
	Vspechab	Presence of special habitat features
	Vpow	% permanent open water
	Sinverts	Index for function – Habitat Suitability for Invertebrates
	Samphib	Index for function – Habitat Suitability for Amphibians
Reducers		
Canopy closed	**V%closure**	% canopy closure over AU
	Index:	(Vbuffcond + Vsnags + Vvegintersp + Vspechab + Vpow + Vedgestruc + Sinverts + Samphib) x (V%closure) / Score for reference standard site

7.10.4 Description and Scaling of Variables

***V**$_{buffcond}$* – Condition of buffer within 100 m of the edge of the AU, as rated by extent of undisturbed areas.

Rationale: The condition of the AU buffer affects the ability of the AU to provide appropriate habitat for some guilds (Zeigler 1992). Trees and shrubs provide screening for birds using the AU, as well as providing additional habitat in the buffer itself (Johnson and Jones 1977, Milligan 1985, and Zeigler 1992). The Assessment Teams judged, however, that good buffers are more important in small AUs, because wetland associated birds can use the interior of a large unit and not be disturbed.

Indicators: This variable is assessed using the buffer categorization described in the data sheets (Part 2).

Scaling: If the AU is greater than 6 ha, the variable is scored a [1]. Smaller AUs with buffers that are vegetated with relatively undisturbed vegetation of at least 100 m around 95% of the AU (buffer category #5) are scored a [1]. The categories between 0-5 are scaled proportionally as 0, 0.2,0.4, 0.6, and 0.8 respectively. **The size threshold is included so large wetlands are not penalized for having poor buffers**.

***V**$_{snags}$* **–** The number of different categories of snags, based on decomposition states, found in the AU.

Rationale: Snags are a source of cavities and perches for wetland associated birds. Several species of birds utilize already existing cavities for nesting and/or refuge locations. The presence of cavities in standing trees can indicate the relative age or maturity of the trees within the AU, and therefore the structural complexity present. Dead wood attracts invertebrates and other organisms of decay, which in turn provide a food source for many species of birds (Davis et al. 1983).

Indicators: The number and size of cavities in an AU cannot be measured directly because they may be difficult to count and measure. Eight different categories of snags representing different levels of decay are used as the indicator for the different potential sizes of cavities. It is assumed that cavities will form or be excavated if dead branches or trunks are present.

Scaling: If a depressional closed AU has 6 or more of the 8 categories of snags present it scored a [1]. Fewer categories are scaled as proportional to 6 (i.e. # of categories/6).

$\boldsymbol{V_{vegintersp}}$ – The relative interspersion between Cowardin vegetation classes (Cowardin et al. 1979).

Rationale: Vegetation interspersion is the relative position of plant types to one another. As an example, an AU may have an emergent marsh of cattails; a nearby shrub/swamp of willows; and an adjacent area of alder swamp. This AU contains three Cowardin classes - emergent, shrub, and forest. For some bird species, this is irrelevant, as many species are single habitat type users. Other species, though, may require several habitat types to being close proximity to aid their movements from one type to another (Gibbs 1991, Hunter 1996).

Indicators: The amount of interspersion between vegetation classes is assessed using diagrams developed from those found in the Washington State Rating System (WDOE 1993).

Scaling: AUs with more interspersion between vegetation classes score higher than those with fewer. The method has four categories of interspersion (none, low, moderate, high) and these are used as the basis for developing a scaled score. A high level of interspersion is scored a 1, a moderate a 0.67, a low = 0.33, and none = 0.

$\boldsymbol{V_{edgestruc}}$ – The vertical structure and linear characteristics of the AU edge.

Rationale: The configuration (e.g., length of shoreline in relation to area) and differences in vegetation strata along the edge of the AU are important habitat characteristics for many species of wetland associated birds. Additional habitat exists within vegetated lobes and scalloped edges of AUs with a differences in edge strata and the shape of the AU edge.

For example, a simple AU may be a nearly circular pond with a fringing emergent marsh composed of cattails, which adjoin immediately to an upland of grazed pasture. The edge of the AU in this case is characterized as having low structural complexity (lack of shrubs and trees), and low linear complexity (as the edge is nearly circular, with no embayments or peninsulas). In contrast, a more complex AU may adjoin with an upland composed of trees and shrubs, adding to the structural complexity, and may be irregular along the edge, with many twists and turns, resulting in enclosed bays and jutting peninsulas. Further, embayments and peninsulas provide "micro-habitats" for certain species that require hiding cover, or "feel" more secure within a more enclosed system (USDI 1978, Verner et al. 1986, and WDOE 1993).

Indicators: The structure of the AU/upland edge is assessed by using a descriptive key that groups the edges and vertical structure along the edge into "high" structural complexity, medium, low, and none.

Scaling: AUs with a high structural complexity at the edge are scored a [1]; moderate = 0.67, low = 0.33, and none = 0.

$\boldsymbol{V_{spechab}}$ **–** Special habitat features that are needed or used by aquatic birds. Five different habitat characteristics are combined in one variable:

1) the AU is within 8 km (5 mi) of a brackish or salt water estuary;
2) the AU is within 1.6 km (1 mi) of a lake larger than 8 ha (20 acres);
3) the AU is within 5 km (3 mi) or an open field greater than 16 ha (40 acres);
4) the AU has upland islands of at least 10 square meters (108 square feet) surrounded by open water (the island should have enough vegetation to provide cover for nesting aquatic birds); and
5) the AU has unvegetated mudflats.

Rationale: The suitability of an AU as habitat for aquatic birds is increased by a number of special conditions. Specifically, the proximity of an AU to open water or large fields increases its utility to migrant and wintering waterfowl. If there is strong connectivity between relatively undisturbed aquatic areas the suitability as habitat is higher (Gibbs et al. 1991, and Verner et al. 1986). In addition, islands surrounded by open water provide a protected nesting area for ducks if they have adequate cover. Mudflats are an important feeding area for migrating birds.

Indicators: No indicators are needed for this variable because the presence of the special habitat features can be determined on site, from maps, or aerial photos.

Scaling: If an AU has 2 or more of the 5 habitat features it is scored a [1]. AUs with one habitat feature score a [0.5] for the variable, and those with none score a [0].

V_{pow} – The percent area of the AU that is covered by permanent open water.

Rationale: Permanent open water provides refuge for many species of waterfowl. The presence of open water allows for the establishment of aquatic vegetation beds, which also provides food for different species of waterfowl.

In addition, open water of varying depths provides greater diversity of foraging habitat for a greater variety of water birds (USDI 1978). Shallow water areas (less than 20 cm deep) provide habitat for rails and teal. The permanent open water should be present throughout the breeding season for maximum functional benefit (Eddelman et al. 1988). To simplify the models the Assessment Teams decided that the variable "permanent open water" is more appropriate than trying to determine whether the water is open during the breeding season. It is understood that some AUs may have open water during the breeding season, but then completely dry up in the late summer. It is too difficult however to establish the presence of open water only during the breeding season.

The extent of the permanent open water required for different scaled scores is based on an educated guess by the Assessment Team, reflecting the need to provide a rapid method. Areas of open water that are smaller than .1 hectare (1/4 acre), or less than 10% of an AU (if it is < 1 hectare), are difficult to determine from aerial photos.

Indicators: The extent of permanent open water in a AU can be easily determined during the dry summer months and no indicator is needed. There is a problem, however, in establishing the size during the wet season when the AU is flooded to its seasonal levels. The indicators that have been suggested to establish the extent of permanent inundation are the edge of emergent vegetation in the deeper portions of a AU, or the presence of aquatic bed vegetation such as *Nuphar spp*.

Scaling: AUs with 30%, or more, of their area covered in permanent open water are scored a [1] for this variable. AUs with a smaller area are scaled proportionally (%open water/30).

$S_{inverts}$ – The habitat suitability index from the Invertebrate function.

Rationale: The index is used to represent the availability of invertebrates as prey for birds.

Indicators: No indicators are needed. The variable is an index from another function.

Scaling: The index is already scaled and re-normalized to 0 –1.

S_{amphib} – Habitat suitability index for the Amphibian function.

Rationale: The index is used to represent the availability of amphibians as prey for birds.

Indicators: No indicators are needed. The variable is an index from another function.

Scaling: The index is already scaled and re-normalized to 0 –1.

S_{fish} – Habitat suitability index for the Fish function. The assessment methods have two functions to characterize habitat suitability for fish (anadromous and resident). The higher of the two scores is used in this model.

Rationale: The index is used to represent the availability of fish as prey for birds.

Indicators: No indicators are needed. The variable is an index from another function.

Scaling: The index is already scaled and re-normalized to 0 –1.

$V_{canopyclos}$ **–** The percent of the AU with a canopy closure of woody vegetation in the AU that is >75%. **This variable reduces the suitability of an AU as bird habitat as it discourages access by certain wetland associated birds such as herons.**

Rationale: A full canopy can limit access to any water in the AU because birds have difficulty flying in and out. This may be best illustrated by great blue herons *(Ardea herodia)*, which will be reluctant to fly down to a body of water if the tree canopy above is totally closed, because rapid escape may be difficult or impossible (USDI 1978).

Indicators: No indicators are needed for this variable because the percent canopy closure can be estimated during the site visit or from aerial photos.

Scaling: AUs with a canopy closure greater than 70% have their suitability score reduced by a factor of 0.7.

7.10.5 Calculation of Habitat Suitability

Depressional Closed – Habitat Suitability for Wetland-associated Birds

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 5 or AU > 6ha	If D1> = 6 or D42 = 5, enter "1"	
	High:	Buffer category of 4	If D1< 6 and D42 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D1< 6 and D42 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D1< 6 and D42 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D1< 6 and D42 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D1 < 6 and D42 = 0, enter "0"	
Vsnags	*Highest:*	At least 6 categories of snags	If D31 > = 6, enter "1"	
	Lowest	No snags present	If D31 = 0, enter "0"	
	Calculation:	Scaled as # categories/6	Enter result of calculation	
	If D31 < 6 calculate D31/6 to get result			
Vvegintersp	*Highest:*	High interspersion	If D39 = 3, enter "1"	
	Moderate:	Moderate interspersion	If D39 = 2, enter "0.67"	
	Low:	Low interspersion	If D39 = 1, enter "0.33"	
	Lowest:	No interspersion (1 class only)	If D39 = 0, enter "0"	
Vedgestruc	*Highest:*	High structure at edge of AU	If D41 = 3, enter "1"	
	Moderate:	Moderate structure	If D41 = 2, enter "0.67"	
	Low:	Low structure	If D41 = 1, enter "0.33"	
	Lowest:	No structure	If D41 = 0, enter "0"	
Vspechab	*High:*	AU has > = 2 of 5 special habitat features	If sum (D8.5 + D27 + D28 + D29 + D33) > = 2, enter "1"	
	Moderate:	AU has 1 of 5 special habitat features	If sum (D8.5 + D27 + D28 + D29 + D33) = 1, enter "0.5"	
	Lowest:	AU has no special habitat features	If sum (D8.5 + D27 + D28 + D29 + D33) = 0, enter "0"	
Vpow	*Highest:*	AU has > = 30% perm. open water	If D8.3 > = 30, enter "1"	
	Lowest:	AU has no permanent open water	If D8.3 = 0, enter "0"	
	Calculation:	Scaled as % open water/30	Enter result of calculation	
	If D8.3 < 30 calculate D8.3/30 to get result.			
Sinverts	*Scaled score:*	Index for Invertebrates	Use (index of function)/10	
Samphib	*Scaled score:*	Index for Amphibians	Use (index of function)/10	
			Total of Variable Scores:	
Reducer				
V%closure	Canopy closure > 70%		If D17 > 70, enter "0.7"	
	Canopy closure < = 70%		If D17 < = 70, enter "1"	
			Score for Reducer	
Index for Habitat Suitability for Wetland-associated Birds = Total for variables x reducer x 1.45 rounded to nearest 1				
			FINAL RESULT:	

7.11 Habitat Suitability for Wetland Associated Mammals — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.11.1 Definition and Description of Function

Habitat Suitability for Wetland-associated Mammals is defined as wetland features and characteristics that support life requirements of four aquatic or semi-aquatic mammals. Mammalian species whose habitat requirements were modeled are the beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), and mink (*Mustela vison*).

The model for this function is based on general habitat requirements for each of the four wetland-associated mammals. The model reflects the suitability of an AU to support mammal richness rather than individual species abundance. Habitat considerations in the model are restricted to the condition of the wetland buffer, and characteristics that can be found within the AU itself. It is assumed that wetlands that provide habitat for all four of the aquatic mammal species function more effectively than ones that meets the habitat needs of fewer species.

Wetlands that are found within urban or residential areas are modeled as having a reduced level of performance. Adjacent areas that are developed provide an avenue for humans, cats, dogs, and other domestic animals to harass mammal populations.

The SWTC and Assessment Teams decided to focus the model specifically on the aquatic fur-bearing mammals because these are wetland dependent species that are important to society, and they represent different types of mammals that use wetlands. Many terrestrial mammals will use wetlands, if they are available, to meet some of their life maintenance requirements. These species, however, do not need wetlands. It would have been too difficult to develop a mammal model that incorporates habitat features for all mammals using wetlands. Such models would have had to incorporate too much information about the surroundings uplands and expanded the scope of the assessment methods to the extent that they would no longer be considered "rapid."

If the AU is a habitat type that appears to be critical to a specific species, another method is needed in order to determine the habitat suitability of that AU (e.g. USFWS Habitat Evaluation Procedures (HEP), USFWS 1981).

7.11.2 Assessing this Function for Depressional Closed Wetlands

The suitability of wetlands in the depressional closed subclass as mammal habitat is modeled by buffer conditions, water depths, presence of open water, connectivity of the site to other suitable habitat, interspersion of vegetation and open water, and the presence of characteristics important to each species modeled. The index for the fish habitat function is added as a variable to reflect the importance fish have in the diet of otters and, to a lesser degree, mink. Reduction in suitability is modeled based on the percentage of the surrounding landscape, within 1 km, that is developed ($V_{upcover}$).

7.11.3 Model at a Glance
Depressional Closed — Habitat Suitability for Wetland-associated Mammals

Characteristics	Variables	Measures or Indicators
Breeding, feeding, and refuge for beaver, mink, otter, and muskrat (applies to all variables)	**Vbuffcond**	Descriptive table of buffer conditions
	Vwaterdepth	Number of water depth categories present
	Vcorridor	Categorical rating of corridor
	Vbrowse	Area of woody vegetation for beaver
	Vemergent2	At least .25 ha of emergent vegetation
	Vwintersp2	Diagrams of interspersion if AU
	Vow	% of AU in open water and aquatic bed
	Vbank	Banks present of fine material
Reducers		
Development	**Vupcover**	Land uses within 1 km of AU
Index:		(Vbuffcond + Vwaterdepth + Vcorridor + Vbrowse + Vemergent2 + Vwintersp2 + Vow + Vbank) x Vupcover / Score for reference standard site

7.11.4 Description and Scaling of Variables

$V_{buffcond}$ – Land-use patterns within 100 m of the edge of the AU.

Rationale: A relatively undisturbed buffer serves to minimize disturbance (Burgess 1978, Allen and Hoffman 1984), provide habitat for prey species and food sources for mammals (Brenner 1962, Dunstone 1978, Allen 1983), cover from predators (Melquist et al. 1981), and den sites for resting and reproduction for wetland associated mammals (Allen 1983). Both live standing vegetation and dead decaying plant material are important components of good buffer conditions.

Indicators: This variable is assessed using the buffer categorization described in the data sheets in Part 2.

Scaling: AUs with buffers that are vegetated with relatively undisturbed plant communities of at least 100 m around 95% of the AU (buffer category #5) are scaled a [1]. The categories between 0-5 are scaled proportionally as 0, 0.2,0.4, 0.6, and 0.8 respectively.

$V_{waterdepth}$ – The varying depths of water present in an AU during the dry season.

Rationale: Adequate water depth is an essential criterion for beaver and muskrat. These aquatic rodents are vulnerable to predation when water depths are shallow. Declines in water level expose lodge or bank burrow entrances to predators. Further, permanent water conditions increase the potential for a resident fish population which serves as a stable food supply for mink and river otters.

Indicators: The variable is scored using a condensed form of the depth classes developed for WET habitat assessments (Adamus et al. 1987). These are 0-20 cm, 20-100 cm, and >100 cm.
Scaling: AUs with water depths greater than 1 m are scored a [1] for this variable. Those with water depths between 1-100 cm are scored a [0.5]; those with depths between 1-20 cm are scored a [0.3]; and those with water depths less than 1 cm are scored a [0].

***V**corridor* – The type of vegetated connections present between the AU and other nearby habitat areas.
Rationale: This variable characterizes the connection of the AU to other relatively undisturbed areas capable of providing mammal habitat. Adolescent mammals born and raised within an AU use natural riparian corridors to move from their natal area to unoccupied habitat. Riparian corridors that have relatively undisturbed vegetation cover ensure that dispersing animals are capable of reaching and populating or repopulating unoccupied habitat. Further, mink and river otter have a number of core activity areas within a larger home range. A loss of adequate travel corridors between core activity areas has potential to restrict or eliminate mammal use if the area of suitable habitat drops below required levels.
Indicators: This variable is determined using a modified corridor rating system developed in the Washington State Rating System (WDOE 1993.) Corridors are rated on a scale of 0-3 (Part 2).
Scaling: AUs rating a 3 for their corridor connections are scored a [1] for this variable. Those with a rating of 2 are scored [0.67]; those with a rating of 1 are scored [0.33]; and those with a rating of 0 are scored [0].

***V**browse* – This variable characterizes the presence of woody deciduous plants that beavers prefer as a primary food source.

Rationale: Woody deciduous species commonly used by beaver include willow (*Salix spp*.), aspen (*Populus tremuloides*) cottonwood (*Populus spp.*) (Denney 1952). Trees and shrubs closest to the AU edge are generally used first (Brenner 1962). In a California study, 90% of all cutting of woody material was within 100 feet of the AU edge (Hall 1970). Red alder (*Alnus rubra*) is also a common food source in the lowlands of western Washington.
Indicators: This variable is determined by estimating the amount of alder, willow, aspen and cottonwood within the AU, and/or within a 100 m buffer around the AU.
Scaling: This is an "on/off" variable. AUs with more than 1 hectare (2.5 acres) of willow, aspen, or cottonwood in them or in their buffer will score a [1]. AUs with less will score a [0]. The size is threshold based on the data collected during the field calibrations and the judgements of the Assessment Teams regarding suitable beaver habitat. Literature for areas outside the Pacific Northwest suggests that much larger areas are needed to sustain a beaver family (Denney 1952), but the Assessment Teams judged these numbers were not appropriate.

***V**emergent2* – Emergent plants are present in the AU that cover more than 0.4 ha (1 acre).
Rationale: Muskrat and beaver use persistent emergent cover for security and feeding (Errington 1963, Jenkins 1981). Muskrats also use this vegetation as material for lodge construction (Wilner et al. 1980). Allen (1983) believes that beaver prefer herbaceous vegetation to woody vegetation during all seasons, if available.
Indicators: This variable is estimated using the Cowardin vegetation class "emergent" as an indicator of the amount of persistent emergent vegetation used by the mammals.
Scaling: This is an "on/off" variable. AUs with an area of emergent vegetation that is larger than 0.4 ha score a [1] for the variable. AUs that do not meet this criterion score a [0]. AUs need to have a minimum of 0.4 ha in emergent cover to score for this variable. Muskrats appear to prefer the greatest of aerial coverage in emergent cover. The size threshold is based on the judgement of the Assessment Teams. 0.4 ha are considered to be the minimum area necessary to maintain a family of muskrats or beaver.

***V**wintersp2* – The amount of interspersion present between vegetated areas of the AU and permanent open water if the AU is at least 0.4 ha (1 acre) in size.
Rationale: For muskrat and beaver, interspersion of vegetation and open water equates to the ease of access to feeding and lodge building sites, and food availability for mink and otter. A diverse mixture of open water and emergent vegetation distributed in a mosaic fashion is assumed to support the largest numbers of muskrats. Beaver colony territories are distinct and non-overlapping (Bradt 1938). High

interspersion rates that optimize prey levels (i.e., muskrats, water birds, and fish) optimize food abundance and availability for mink and river otter. King (1983) reported that habitat quality influences the distribution, density, and reliability of prey, which, in turn, directly affect mink population density and distribution. Food abundance and availability appeared to have the greatest influence on habitat use by river otter in Idaho (Melquist and Hornocker 1983). Classic muskrat studies by Dozier (1953) and Errington (1937) indicate that optimum muskrat habitat has approximately 66 to 80% of the AU in emergent vegetation with the remainder in open water.

A size threshold is included in this variable because the Assessment Teams assumed that very small AUs are not suitable habitat even if they have good interspersion between vegetated parts and the open water.

Indicators: The interspersion in an AU is assessed using a series of diagrams that rates the interspersion as high, moderate, low, and none. The size of the AU is estimated from maps or aerial photos.

Scaling: If an AU is less than 0.4 ha in size it is scored a [0] for this variable. If it is larger, then AUs with high interspersion are scored a [1]; those with moderate are scored [0.67]; those with low = [0.33], and those with no interspersion (i.e. no permanent open water) = [0].

V_{ow} – The percentage of the AU that has open water. This includes the areas of permanent open water and that can be classified as "aquatic bed" vegetation using the Cowardin (1979) classification.

Rationale: For muskrat and beaver open water is needed for feeding and lodge building sites, and access to food for mink and otter. Beaver colony territories are distinct and non-overlapping (Bradt 1938). Classic muskrat studies by Dozier (1953) and Errington (1963) indicate that optimum muskrat habitat has approximately 66 to 80% of the AU in emergent vegetation with the remainder in open water. Beavers need an unknown, but lesser proportion, of open water.

A size threshold of 0.1 ha is included in this variable because the Assessment Teams assumed that very small areas of open water are not suitable for the mammals.

Indicators: The size of the area that is in permanent open water and aquatic bed vegetation is estimated during the site visit and from maps or aerial photos.

Scaling: If the area of permanent open water and aquatic bed vegetation is less than 0.1 ha (1/4 acre) the variable is scored a [0]. If it is larger, then AUs with at least 30% of their area in open water are scored a [1]; those with less are scored proportionally (% open water/30).

V_{bank} – This variable identifies the presence of slope and soil conditions that are suitable for muskrat, otter, and beaver bank burrows.

Rationale: When studying bank burrowing muskrats, Earhart (1969) found that a minimum bank slope of 10° was required before burrows were consistently observed regardless of soil type. Gilfillan (1947) considered 30° or more slope as optimum conditions for muskrat bank burrows when the bank height exceeds 0.5 meters (1.6 feet). Muskrat and beaver are capable of constructing bank burrows in a wide range of soil conditions. Muskrat studies by Errington (1937) and Earhart (1969) note that clay soils provide the most suitable substrate for burrow excavation, but even soils with high sand content may provide suitable burrowing sites if dense vegetation exists (Errington 1937). Beaver are capable of constructing lodges against a bank or over the entrance of a bank burrow (Allen 1983) and appear to have less specific slope and soil type limitations for bank burrows.

Indicators: No indicators are needed to assess this variable. The presence of banks can be determined during the site visit. A steep bank that can be used for denning must be 1) > 30 degrees 2) more than 0.6 m (2 ft.) high (vertical), 3) of fine material such as sand, silt, or clay.

Scaling: This is an "on/off" variable. AUs meeting the criteria for banks are scored a [1] for the variable. Those with no banks are scored a [0].

$V_{upcover}$ – The types of land uses within 1 km of the estimated AU edge. This variable is used to indicate potential reductions in the level of performance for the function.

Rationale: Human alteration to the AU buffer has direct impacts to the AUs habitat suitability for mammals. These alterations also include the associated negative impacts from harassment by humans and domestic animals. Loss or alteration of the natural areas around an AU has direct adverse impacts to feeding, loafing, and breeding habitat for mink, river otter, and muskrat and beaver. These mammals are vulnerable to harassment and predation by domestic pets (Errington 1937, Slough and

Sadleir 1977, Burgess 1978, and Melquist and Hornocker 1983). This variable is in contrast to $V_{buffcond}$, which gives a positive value rating to buffers in good condition. Two variables were needed to represent upland conditions because $V_{buffcond}$ does not address the issue of disturbances to mammals from specific adjacent land uses.

Indicators: No indicators are needed to assess this variable. The amount and type of land uses within 1 km of the AU can be established from aerial photographs or site visits.

Scaling: AUs with at least 15% of their surrounding land in urban land uses, or at least 20% high density residential use, or at least 40% low density residential land use, have their index for the function reduced by a factor of 0.7.

7.11.5 Calculation of Habitat Suitability

Depressional Closed – Habitat Suitability for Wetland-associated Mammals

Variable	Description of Scaling		Score for Variable	Result
Vbuffcond	*Highest:*	Buffer category of 5	If D42 = 5, enter "1"	
	High:	Buffer category of 4	If D42 = 4, enter "0.8"	
	Moderate:	Buffer category of 3	If D42 = 3, enter "0.6"	
	Medium Low:	Buffer category of 2	If D42 = 2, enter "0.4"	
	Low:	Buffer category of 1	If D42 = 1, enter "0.2"	
	Lowest:	Buffer category of 0	If D42 = 0, enter "0"	
Vwaterdepth	*Highest:*	Water depths >1 m present	If D12.3 = 1, enter "1"	
	Moderate:	Water depths between 1-100 cm present	If D12.1 = 1 **and** D12.2 = 1, enter "0.5"	
	Low:	Depths between 1-20 cm present	If D12.1 = 1, enter "0.3"	
	Lowest:	No surface water present	If all D10 are 0, enter "0"	
Vcorridor	*Highest:*	Corridor rating is 3	If D43 = 3, enter "1"	
	Moderate:	Corridor rating is 2	If D43 = 2, enter "0.67"	
	Low:	Corridor rating is 1	If D43 = 1, enter "0.33"	
	Lowest:	Corridor rating is 0	If D43= 0, enter "0"	
Vbrowse	*Highest:*	AU has more than 1 ha (2.5 acres) of preferred woody vegetation for beaver in and within 100 m of AU	If D30 =1, enter "1"	
	Lowest:	Above not present	If D30 = 0, enter "0"	
Vemergent2	*Highest:*	AU has cover of emergent vegetation that is > = 0.4 ha (2.5 acres)	If (D1 x D14.5)/100 > = 0.4, enter "1"	
	Lowest:	AU has no cover of emergents or emergents < 0.4 ha	If (D1 x D14.5)/100 < 0.4, enter "0"	
Vwintersp2	*Highest:*	If AU is > 0.4 ha (2.5 acres) and interspersion between vegetation and open water is high	If D1 > = 0.4 and D38 = 3, enter "1"	
	Moderate:	If AU > 0.4 ha and interspersion is moderate	If D1 > = 0.4 and D38 = 2, enter "0.67"	
	Low:	If AU > 0.4 ha and interspersion is low	If D1 > = 0.4 and D38 = 1, enter "0.33"	
	Lowest:	AU has < 0.4 ha or AU has no interspersion	If D38 = 0 OR D1 < 0.4, enter "0"	
Vow	*Highest:*	If OW > 0.1 ha (2.5 acres) and OW at least 30% of AU	If (D1 x D8.3) / 100 > 0.1 and D8.3 > = 30, enter "1"	
	High:	If OW > 0.1 ha and OW = 10 - 29% of AU	If (D1 x D8.3) / 100 > 0.1 and 10< = D8.3 < 30, enter "0.8"	
	Lowest:	If OW < = 0.1 ha	If (D1 x D8.3)/100 < 0.1, enter "0"	
	Calculation:	If OW > 0.1 ha scaled as % OW x 0.08	Enter result of calculation	
	If (D1xD8.3)/100 > 0.1 and D8.3 < 10 calculate as D8.3x0.08 to get result			

Table continued on next page

Variable	Description of Scaling		Score for Variable	Result
Vbank	*Highest:*	Steep banks suitable for denning (>45 degree slope, fine material, >10 m long)	If D37 = 1, enter “1”	
	Lowest:	No steep banks present	If D37 = 0, enter “0”	
			Total of Variable Scores:	
Reducer				
Vupcover	Land use within 1 km - > = 15% urban commercial, or > = 20% high density residential; or > = 40% low density residential		If D3.4 > = 15 OR D3.5 > = 20 OR D3.6 > = 40, enter “0.7”	
	Land use criteria described above not met		If above conditions not met, enter “1”	
			Score for Reducer	
Index for Habitat Suitability for Wetland-associated Mammals = Total for variables x reducer x 1.33 rounded to nearest 1				
			FINAL RESULT:	

7.12 Native Plant Richness — Depressional Closed Wetlands

Note: Please read the introduction to the assessment models (Chapter 2) before using these models. It describes several basic assumptions used in modeling that will help you better understand how to use and apply the methods.

7.12.1 Definition and Description of Function

Native Plant Richness is defined as the degree to which a wetland provides habitat for a relatively high number of native plant species. An AU is judged to provide habitat for native plants if it contains a diverse group of native plants. This function is the only one where an actual estimate of performance can be made since the number of species can be estimated during a single visit. Many native plants are persistent and can be documented in a rapid assessment method. The assessment of species richness during the site visit is used as a surrogate for total richness. If an AU contains a diverse and mature assemblage of natives it is assumed to perform the function at a high level. Those lacking diverse native plant assemblages and structure are assumed to perform the function at a lower level.

Note: The assumption is valid only if the AU has **not** been recently cleared or altered. If you find the AU has been recently cleared or cut, the index from the model will not provide an adequate assessment of the function.

The Assessment Teams considered using the list of native plant communities developed by Kunze (1994) for western Washington as the basis for the assessment. Attempts to identify the specific plant associations by name, however, proved to be too difficult for most investigators not specifically trained as botanists or plant ecologists.

The Assessment Teams also judged that AUs where one or more of the dominant species is non-native have lost some of their ability to support native plant associations. Non-native plants that become dominant tend to become monocultures that exclude natives. **The percent of the AU dominated, or co-dominated, by non-native species is modeled as a reducer of habitat**.

Note: A variable representing invasive **native** species was considered as a reducer of performance. However, the Assessment Teams decided that the impact of invasive native species was partially addressed in other variables ($V_{prichness}$, V_{assoc}, and V_{strata}). Their presence is reflected in lower scores for those variables. The Assessment Teams judged the presence of non-native species as more detrimental for performance of this function, and an element of the ecosystem in need of highlighting.

7.12.2 Assessing this Function for Depressional Closed Wetlands

Native plant richness in depressional closed wetlands is assessed based on the richness of the existing plant species and assemblages. Variables include the number of plant assemblages in the AU, the richness of plant species, and structural elements such as number of strata and the presence of mature trees. The presence of sphagnum bogs in depressional wetlands is used as an indicator of a potentially very rich native species assemblage that may not be captured by the other variables.

7.12.3 Model at a Glance
Depressional Closed — Native Plant Richness

Process	Variables	Measures or Indicators
Richness of native plant species (applies to all variables)	**Vstrata**	Number of strata present in any plant association
	Vassemb	Number of plant associations
	Vmature	Presence/absence of mature trees
	Vnplants	Number of native plant species
	Vbogs	% of AU covered by sphagnum bog
Reducers		
	Vnonnat	% of AU dominated by non-native plant species
	Index:	(Vstrata + Vassemb + Vmature + Vnplants +Vbogs) x (Vnonnat) / Score from reference standard site

7.12.4 Description and Scaling of Variables

V_{strata} – The maximum number of strata in any single plant association. A plant association can have up to 6 strata (layers: trees, shrub, low shrub, vine, herbaceous, moss). To count as a stratum, however, the plants of that stratum have to have 20% cover in the association in which it is found.

Rationale: Each stratum of a plant association is composed of different plant species. AUs with more strata, therefore, have the potential to support more native plant species than ones with fewer. The number of strata is used as an indicator of plant richness that can be associated with each specific strata that may not be counted during the site visit. These include many mosses and other bryophytes that are not included in a species count.

Indicators: No indicators are needed to assess this variable. The number of strata can be estimated directly at the site.

Scaling: AUs with 5 strata or more are scored a [1] for this variable. AUs with only one are scored a [0.2]. AUs with 2-5 strata are scaled proportionally as 0.2, 0.4, 0.6, and 0.8 respectively. For this function, the vine stratum is not counted if it is dominated by non-native blackberries.

V_{assemb} – The number of plant assemblages in the AU.

Rationale: Each plant assemblage represents a different group of plant species. Even if some plant species are the same between associations, the ecological relationships between the species within the associations are probably different, and represent potential differences in phenotypes. The number of associations, therefore, is one way to characterize the richness of plants in an AU. The procedures for collecting data described in Part 2 provide guidance on how to identify associations in the field.

Indicators: No indicators are needed to assess this variable. The number of associations can be determined in the field.

Scaling: Depressional closed AUs with 6 or more plant assemblages are scored a [1]. AUs with fewer are scaled proportionally.

V_{mature} – The AU has, or does not have, a stand of mature trees present.

Rationale: The model is giving a point for the presence of a stand of mature trees. A mature stand is used as a surrogate for stability, complexity, and structure in plant associations that may not be captured by other variables. The presence of mature trees suggests the AU may contain native plant species that are intolerant of much disturbance and that might not be observed because of their scarcity.

Indicators: This variable is characterized by measuring the dbh (diameter at breast height) of the five largest trees of specific species (see Part 2 for list of species and size criteria). If the average diameter of the three largest of a given species exceed the diameters given in Part 2, the AU is considered to contain a stand of mature trees.

Scaling: This is an "on/off" variable. AUs with mature trees are scored a [1], those without are scored a [0].

$V_{nplants}$ – The number of native plant species present.

Rationale: The number of native plant species assessed during one visit in an AU is one measure of how effective an AU is at providing a diverse habitat for native plants and maintaining regional plant biodiversity. It is not possible, however, to determine the total species richness in one visit and within a few hours. Some plants are annuals and grow for only a short time, others have a very limited distribution and may occupy a small and inconspicuous patch that is easily overlooked. For this reason the count of native species determined during the site visit is only an indicator of the actual number present.

Indicators: The indicator of overall native plant richness is the number of native species found during the site visit.

The Assessment Teams recognize that site observations made during the summer will usually result in a higher count of plant species than those that are done during the winter will. This issue is currently unresolved as most of our calibration occurred during the summer and fall. A different scaling may be developed for winter and summer if further data necessitates.

Scaling: If the AU has 30 or more native species it is scored a [1]. AUs with a fewer number of native species are scaled proportionally (# of native species/30).

V_{bogs} – The percent area of the AU is covered by a sphagnum bog (defined as areas where sphagnum mosses represent more than 30% cover of the ground).

Rationale: Sphagnum bogs are often the habitat for many unique plant species (Mitch and Gosselink 1993). These plants are often small and hard to identify. Also sphagnum bogs often lack the physical structure of many other mature wetland plant communities. The presence of bogs is used as an indicator of a potentially very rich native species assemblage that may not be captured by the other variables.

Indicators: No indicators are needed for this variable since the % area of an AU covered by Sphagnum bog can be determined directly.

Scaling: This is an "on/off" variable. AUs with 25% or more Sphagnum bog are scored a [1]. Those with a bog cover <25% are scored a [0].

$V_{nonative}$ – The percent of the AU where non-native species are dominant or co-dominant (non-native species are listed in Part 2, Appendix L) **This is a variable of reduced performance.**

Rationale: The Assessment Teams judged that wetlands where one or more of the dominant species is non-native have lost some of their potential for maintaining native regional plant biodiversity. Non-native plants that become dominant tend to exclude many of the less common native plants.

Indicators: No indicator is needed for this variable. The areal extent of non-native species can be determined in the field.

Scaling: AUs where non-native species extend over more than 75% of the AU have their index reduced by a factor of 0.5. Those with an extent of 50 – 75% are reduced by a factor of 0.7, and those with an extent of non-native between 25-49% are reduced by a factor of 0.9. AUs where non-native species are dominant or co-dominant on less than 25% of the AU do not have their index reduced.

7.12.5 Calculation of Habitat

Depressional Closed – Native Plant Richness

Variable	Description of Scaling		Score for Variable	Result
Vstrata	*Highest:*	5 strata present (no blackberries)	If D21-D21.1 =5, enter "1"	
	High:	4 strata present "	If D21-D21.1 = 4, enter "0.8"	
	Moderate:	3 strata present "	If D21-D21.1 = 3, enter "0.6"	
	Medium Low:	2 strata present "	If D21-D21.1 = 2, enter "0.4"	
	Low:	1 stratum present "	If D21-D21.1 = 1, enter "0.2"	
	Lowest:	Only stratum = blackberries	If D21-D21.1 = 0, enter "0"	
Vassoc	*Highest:*	AU has at least 6 plant assemblages	If calculation > = 1, enter "1"	
	Lowest:	AU has 1 plant assemblage	If D20 = 1, enter "0.1"	
	Calculation:	Scaling based on the number of assemblages divided by 6	Enter result of calculation	
	Calculate D20/6 to get result			
Vmature	*Highest:*	AU has mature trees present	If D22 = 1, enter "1"	
	Lowest:	AU has no mature trees present	If D22 = 0, enter "0"	
Vnplants	*Highest:*	Number of native plant species > = 30	If calculation > = 1, enter "1"	
	Lowest	AU has 1 or less native species	If D19.1 < = 1, enter "0"	
	Calculation:	Scaled as # of native species/30	Enter result of calculation	
	Calculate (D19.1)/30 to get result			
Vbogs	*Highest:*	AU is at least 25% bog	If D23.1 + D23.2 + D23.3 > = 1, enter "1"	
	Lowest:	AU is less than 25% bog	If D23.4 + D23.5 > = 1, enter "0"	
			Total of Variable Scores:	
Reducer				
Vnonnat	>75% cover of non-native plants		If D24.1 = 1, enter "0.5"	
	50-75% cover of non-native plants		If D24.2 = 1, enter "0.7"	
	25 - 49% cover of non-native plants		If D24.3 = 1, enter "0.9"	
			Score for Reducer:	
Index for Native Plant Richness = Total for variables x reducer x 2.22 rounded to nearest 1				
			FINAL RESULT:	